Northeast Coastal and Barrier Network

Vital Signs Monitoring Plan Phase III

December 15, 2004
Draft

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The Northeast Coastal and Barrier Network

- *Cape Cod National Seashore*
- *Fire Island National Seashore*
- *Sagamore Hill National Historic Site*
- *Gateway National Recreation Area*
- *Thomas Stone National Historic Site*
- *George Washington Birthplace National Monument*
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Chapter 1
Introduction and Background

PURPOSE

1.1 Legislation, Policy, and Guidance

United States Federal law and National Park Service policies direct national park managers to know the status and trends in the condition of natural resources under their stewardship (See Appendix 1.1, *Summary of Laws, Policy, and Guidance_2003*). The misson of the National Park Service (according to the National Park Service Organic Act, 1916):

> "*...is to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations*."

When it amended the Organic Act in 1978, Congress strengthened the protective function of the National Park Service (NPS) and provided language important to recent decisions about resource impairment. The Organic Act states that *"the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established…."*

More recently, the National Parks Omnibus Management Act of 1998 established the framework for fully integrating natural resource monitoring and other science activities into the management processes of the National Park System. This Act charges the Secretary of the Interior to "*continually improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the National Park System*", and to *"… assure the full and proper utilization of the results of scientific studies for park management decisions*." Section 5934 of the Act requires the Secretary of the Interior to develop a program of "*inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources*."

Congress reinforced the message of the National Parks Omnibus Management Act of 1998 in its text of the FY 2000 Appropriations bill:

> *"The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with*

their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."

In 2001, NPS Management Policies updated previous policy and specifically directed the NPS to inventory and monitor natural systems:

"Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions."

Further, *"The Service will:*

- *Identify, acquire, and interpret needed inventory, monitoring, and research, including applicable traditional knowledge, to obtain information and data that will help park managers accomplish park management objectives provided for in law and planning documents*
- *Define, assemble, and synthesize comprehensive baseline inventory data describing the natural resources under its stewardship, and identify the processes that influence those resources*
- *Use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals*
- *Analyze the resulting information to detect or predict changes, including interrelationships with visitor carrying capacities, that may require management intervention, and to provide reference points for comparison with other environments and time frames*
- *Use the resulting information to maintain-and, where necessary, restore-the integrity of natural systems"*

Additional statutes provide legal direction for expending funds to determine the condition of natural resources in parks and specifically guide the natural resource management of Network parks, including:

- Taylor Grazing Act 1934
- Fish and Wildlife Coordination Acts, 1958 and 1980
- Wilderness Act 1964
- National Historic Preservation Act 1966
- National Environmental Policy Act of 1969
- Clean Water Act 1972, amended 1977, 1987
- Endangered Species Act 1973, amended 1982
- Migratory Bird Treaty Act, 1974
- Forest and Rangeland Renewable Resources Planning Acts of 1974 and 1976
- Mining in the Parks Act 1976
- American Indian Religious Freedom Act 1978

- Archaeological Resources Protection Act 1979
- Federal Cave Resources Protection Act 1988
- Clean Air Act, amended 1990

1.2 Justification for Integrated Natural Resource Monitoring

Knowing the condition of natural resources in its national parks is fundamental to the NPS's ability to manage park resources. National park managers are confronted with increasingly complex and challenging issues that require a broad-based understanding of the status and trends of park resources. A broad-based understanding is necessary for making decisions and for working with other agencies and the public. For years, managers and scientists have sought a way to characterize and determine trends in the condition of parks and other protected areas. Managers need to assess the efficacy of management practices and restoration efforts, and they need to provide early warning of impending threats. Since most parks are open systems, the challenge of protecting and managing a park's natural resources hinges on a partnership-based, ecosystem-wide approach. Threats, such as air and water pollution or invasive species, often originate outside of a park's boundaries. In these cases, understanding and managing resources may require a regional, national, or international effort.

The NPS needs an ecosystem approach because no single spatial or temporal scale is appropriate for all system components and processes. The appropriate scale for understanding and effectively managing a resource might be at the population, species, community, or landscape level. National parks are part of larger ecosystems and must be managed in that context.

Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making intended to maintain, enhance, or restore the ecological integrity of park ecosystems, while avoiding, minimizing, and mitigating ecological threats to these systems (Roman and Barrett 1999; See Appendix 1.2, *CACO Conceptual Framework_Roman_Apr 1999*). Natural resource monitoring provides site-specific information needed to understand and identify changes in complex, variable, and imperfectly understood natural systems. Monitoring provides a basis for understanding and identifying *meaningful change* in natural systems characterized by complexity, variability, and surprises. By monitoring data, we can define the normal limits of natural variation in park resources and provide a basis for understanding observed changes. The information we obtain from monitoring may also be useful in determining what constitutes impairment and in identifying the need to initiate or change management practices.

In highly altered environments where natural physical and biological processes no longer predominate (e.g., control of fires and floods in developed areas), information obtained through monitoring can help managers develop effective approaches to restoration, and where restoration is impossible, ecologically sound management. The broad-based, scientifically sound information obtained through natural resource monitoring will have multiple applications for management decision-making, research, education, and promoting public understanding of park resources.

THE NATIONAL PARK SERVICE INVENTORY AND MONITORING PROGRAM

1.3 Program Approach and Strategy

Ecological monitoring is now a central component of natural resource stewardship in the NPS, and along with natural resource inventories and research, provides information needed for effective, science-based decision-making and resource protection (See Figure 1.1; also see Appendix 1.3, *Definitions of Natural Resource Inventories, Monitoring, & Research_2003*). The strategy of the NPS Inventory and Monitoring Program consists of a framework of three major components:

- Completion of 12 resource inventories upon which monitoring efforts can be based
- Eleven experimental or "prototype" long-term ecological monitoring (LTEM) programs
- Monitoring of "vital signs" by 32 Inventory and Monitoring Networks

Each Network consists of a group of parks linked by shared natural resource and geographic characteristics. The 32 Networks contain approximately 270 parks.

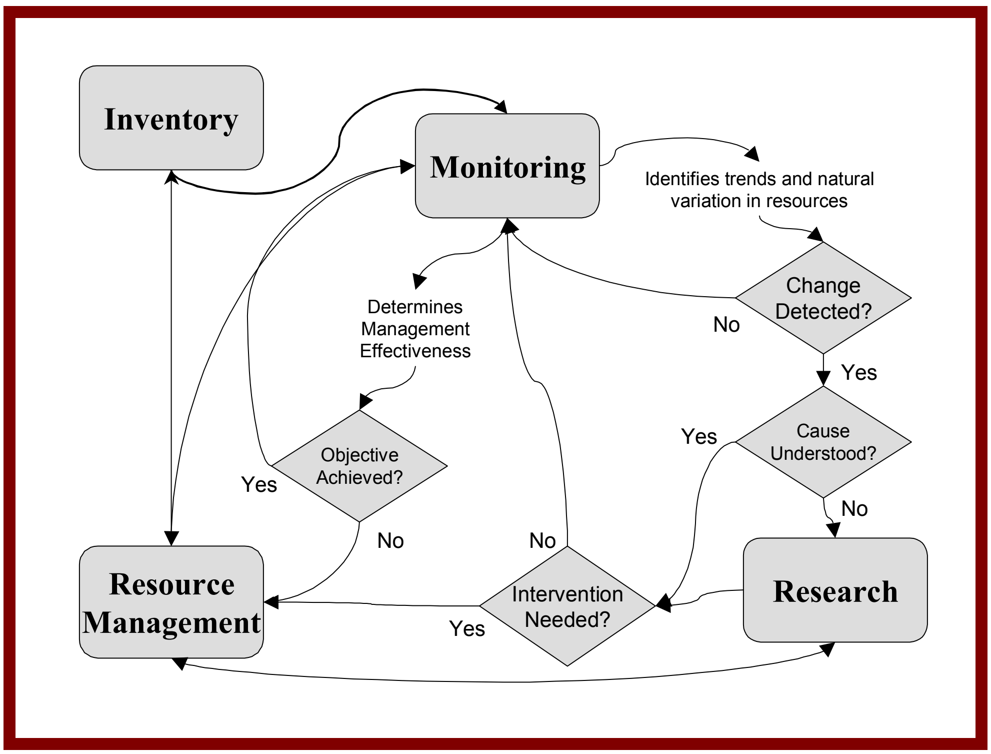

Figure 1.1 Relationships between monitoring, inventories, research, and natural resource management activities in National parks (modified from Jenkins *et al*. 2002)

In 1992, the NPS began establishing its 12 prototype Long-Term Ecological Monitoring (LTEM) programs at selected parks. These programs are experiments in learning how the NPS can design scientifically credible and cost-effective monitoring programs in ecological settings of major importance. These prototypes are well-funded and staffed, and they benefit from USGS involvement and funding in program design and protocol development. For example, the Cape Cod NS, which the NPS established as an LTEM program site in 1996, serves as the prototype park for the NCBN (Northeast Coastal and Barrier Network). See Appendix 1.3, *Definitions of Natural Resource Inventories, Monitoring, & Research_2001*.

Each Network of parks is required to design an integrated monitoring program tailored to the high-priority monitoring needs and partnership opportunities for the parks in that Network. This Networked approach to long-term ecological monitoring will facilitate collaboration, information sharing, and economies of scale in natural resource monitoring. It will provide parks with a minimum infrastructure for initiating natural resource monitoring that can be expanded as needed. Although each Network's monitoring program will differ in implementation, its initial design will consist of three phases based on the following set of guidelines:

- Define the purpose and scope of the monitoring program
- Compile and summarize existing data and understanding of park ecosystems
- Develop conceptual models of relevant ecosystem components
- Select indicators and specific monitoring objectives
- Determine the appropriate sampling design and sampling protocols

Also, see Appendix 1.4, *Framework for NPS Inventory & Monitoring_2003: Recommended Approach for Developing a Network Monitoring*.

In Phase I, a Network defines goals and objectives, identifies, evaluates, and synthesizes existing data, then develops draft conceptual models. Any background research needed before the initial selection of ecological indicators occurs in this phase. In Phase II, a Network prioritizes and selects vital signs. It then develops specific monitoring objectives for each vital sign. In Phase III, a Network details any design work needed to implement monitoring, including the development of sampling protocols, a statistical sampling design, a plan for data management and analysis, and details on the type and content of various products of the monitoring effort such as reports and websites.

1.4 Vital Signs Monitoring

We can not monitor all natural resources simultaneously. Thus, we monitor vital signs, which we define "as a subset of physical, chemical, and biological elements and processes of park ecosystems selected to represent the overall health or condition of park resources." Vital signs monitoring will enable the NPS to determine the status and trends in selected indicators of the condition of park ecosystems. It will allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources. The NPS vital signs monitoring program will provide:

- early warning of abnormal conditions and impairment of selected resources, which will aid the development of effective mitigation measures and reduce the costs of management
- data to aid the understanding of the dynamic nature and condition of park ecosystems
- reference points for comparisons with other altered environments
- data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment
- a means of measuring progress towards performance goals

We must be able to monitor a vital sign via one or more measurable parameters. A balanced monitoring approach includes vital signs that reflect four categories of park resources and influences:

- **Ecosystem Agents of Change** that fundamentally affect park ecosystems
- **Stressors** and their ecological effects on the ecosystem **(Ecosystem Responses)**
- **Focal Resources** of parks
- **Key Properties and Processes of Ecosystem Integrity**

Agents of change are the major external activities or processes that influence an ecosystem (natural processes or human activities). These include a rise in sea level, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., hurricanes, droughts, floods) that can have large scale influences on ecosystems. Trends in agents of change will suggest the kinds of changes we can expect. These may provide an early warning of presently unforeseen changes to the ecosystem.

Stressors are the associated problems or products of human activities or natural events that alter the quality or integrity of the ecosystem (problems emerging from or related to the agents of change). Stressors cause significant changes in the ecological components, patterns, and processes in natural systems. Examples include altered hydrologic properties, altered landscape, invasive species, altered sediment, and chemical inputs. Monitoring of stressors and their effects, where known, will ensure short-term relevance of the monitoring program and provide information useful to management of current issues.

Focal resources, by virtue of their special protection, public appeal, or other management significance, have paramount importance for monitoring. Focal resources might include ecological processes such as deposition rates of nitrates and sulfates in certain parks; or they might include a species that is harvested, endemic, historically significant, or has protected status.
We can define biological integrity “as the capacity to support and maintain a balanced, integrated, adaptive community of organisms that have a species composition, diversity, and functional organization comparable to that of natural habitats of the region” (Karr and Dudley 1981). Monitoring of key properties

and processes of ecosystem integrity provides the long-term baseline we need to determine unnatural variation in park resources. More importantly, it serves as an early warning of unacceptable change.

1.5 Water Quality Inventory and Monitoring in Vital Signs Monitoring

The NPS Water Resources Division has funded a water quality monitoring component for each Network. The implementation plan for this component is keyed to the concept of fully integrating the design and implementation of water quality monitoring with the Network-based vital signs monitoring program. Each Network incorporates the three-phase approach described earlier and follows the same implementation schedule for water quality monitoring. Networks, optionally, can produce a single, integrated monitoring plan that incorporates the "core vital signs" as well as the water quality monitoring components. Or they can produce a separate document for the water quality monitoring component. The NCBN will produce a single, integrated monitoring plan that incorporates both the core vital signs and water quality monitoring. See Appendix 1.5, *Program_2003*.

DEVELOPMENT OF AN INTEGRATED MONITORING PROGRAM FOR THE NORTHEAST COASTAL AND BARRIER NETWORK

1.6 Overview of Network Parks and Natural Resources

The NCBN includes eight parks that extend along the coast of the Northeastern United States from Massachusetts to Virginia (see Table 1.1). These parks represent some of the most ecologically similar collections of lands within the Park Service. They consist of critical coastal habitat for many rare and endangered species, as well as migratory corridors for birds, sea turtles and marine mammals. They also protect vital coastal wetlands, essential to water quality, fisheries, and the biological diversity of coastal, near shore, and terrestrial environments. Table 1.7 presents a summary of ecosystem types in the NCBN parks.

As part of the Atlantic coastline, parks in the Northeast Coastal and Barrier Network represent islands of protected lands within the urban sprawl of the Northeast. Sixteen percent of the United States population resides in the coastal zone (Culliton, *et al*. 1990). Census estimates indicate that populations within this zone are growing three times faster than the United States population (Culliton *et al*. 1989). To maintain or restore ecosystem health in our parks, we need to understand how urban pressure affects park ecosystems. Developing a long-term monitoring program is fundamental to this understanding, and to how we protect and manage our natural resources.

Key components in developing a monitoring program are data collection, information management, preparation of data summaries and interpretive reports, feedback to park resource management, and program coordination and support. For a detailed descriptions of natural resources and management issues, as well as an overview of special habitats that occur in each park. See Appendix 1.6, *Park*

Descriptions_Sep 2003. For brief park descriptions, see Table 1.1. For a summary of water quality information for each park, see Table 1.2.

Table 1.1 Northeast Coastal and Barrier Network Park Members

Park Name	Code	State	Hectares	Acreage
Assateague Island National Seashore	ASIS	MD,VA	19,200	48,000
Cape Cod National Seashore	CACO	MA	17,442	43,604
Gateway National Recreation Area	GATE	NY, NJ	10,644	26,610
Fire Island National Seashore	FIIS	NY	7,832	19,580
Colonial National Historical Park	COLO	VA	3,740	9,350
George Washington Birth Place NM	GEWA	VA	220	550
Thomas Stone National Historic Site	THST	MD	129	322
Sagamore Hill National Historic Site	SAHI	NY	33	83

Table 1.2 Northeast Coastal and Barrier Network significant ecosystem types

Ecosystem Type	CACO	FIIS	SAHI	GATE	ASIS	THST	GEWA	COLO
Salt Marsh/Tidal Flats	X	X	X	X	X		X	X
Heathlands	X							
Coastal Grasslands	X			X			X	
Kettle Ponds	X		X					
Vernal Ponds	X	X	X	X	X	X	X	X
Red Maple swamps	X			X		X	X	X
White Cedar swamps	X							
Hardwood forests			X	X		X	X	X
Maritime Holly Forest		X		X				
Eel-grass beds	X	X	X	X	X			X
Riparian				X		X	X	X
Beach	X	X	X	X	X		X	X
Dunes	X	X		X	X		X	
Freshwater wetlands	X	X	X	X	X	X	X	X
Estuaries	X	X	X	X	X		X	X

Assateague Island National Seashore (ASIS) encompasses more than 19,000 hectares, more than half of which consists of oceanic and estuarine waters surrounding the Island. Located near the Washington/Baltimore/Philadelphia metropolitan area, ASIS hosts more than 1.8 million visitors every year. Natural resources include coastal geological features and beach, dune, and marsh communities supporting aquatic and terrestrial plants and wildlife, including Assateague's renowned free-roaming feral horses. The physical and ecological processes at ASIS reflect the complexity of the land/sea interface along the Mid-Atlantic coast, and demonstrate the adaptive extremes necessary for survival on a barrier island, where exposure to salt spray, lack of fresh water, and shifting sands create a harsh and dynamic environment.

1.7 ASIS Water Quality

The predominant water resources of ASIS are estuarine and ocean areas surrounding the island. The majority of wetlands within ASIS are salt marsh pools that receive water from the surrounding bays and ocean through over-wash and tidal inundation. ASIS is an undeveloped barrier island, and land use within the park strongly influences the nutrient status of these waters. The few perennial freshwater water bodies occur in dune slacks and other basins.

Water quality is degraded in and around ASIS by nutrient and sediment enrichment. These changes are thought to derive from poorly planned recreational use of the bays and unsustainable growth and development, which include marinas, poultry and agricultural operations, and residential developments. The majority of non-point sources of nitrogen come from agricultural runoff and atmospheric deposition. Point sources include sewage treatment plants and industrial discharges. A 1995 NPS report concluded that surface waters within ASIS are generally of good quality with some indications of impacts from human activities. Since most surface waters are salt marsh pools, they are mostly affected by similar impairments to the surrounding estuarine waters.

The waters of Assateague Channel, Sheepshead Creek, and Tom's Cove have a Virginia Department of Health (VDH) shellfish restriction due to non-point source pollution. Portions of Chincoteague and Sinepuxent Bays are impaired by fecal coliform, nutrients, and low dissolved oxygen, from both non-point and natural sources, and are closed to shell fishing. Also, the outlets of Trappe Creek and Newport Bay have been identified as water quality problem areas due to elevated nutrient and bacteria levels.

The Maryland Coastal Bays Program (MCBP) manages Sinepuxent Bay and the northern portion of Chinocteague Bay as a National Estuary Program estuary. Both watersheds are listed as Category 1 and Category 3 watersheds by the Maryland Clean Water Action Plan. Category 1 watersheds do not meet clean water and other natural resource goals and need restoration. Category 3 watersheds are pristine or sensitive watersheds that are in need of extra protection. Chincoteague Bay received this rating due to historic wetland loss (estimated at 11,600 ha) and its 303(d) listing. Sinepuxent Bay received its rating due to a high percent (79%) of unbuffered streams and its 303(d) status.

Cape Cod National Seashore (CACO) preserves 17,442 hectares of uplands, wetlands and tidal lands located on Outer Cape Cod, Massachusetts. The park contains an exceptional array of coastal communities, including pitch pine/oak forests, heathlands (nearly the entire eastern U.S. distribution of heathlands is restricted to fragments on the Outer Cape and in coastal Maine), dunes, and coastal plain pond shores. Also, there are many diverse aquatic and marine habitats, such as kettle ponds, cedar swamps, vernal pools, drowned river valley salt marshes, back barrier salt marshes, and inter-tidal mudflats. CACO serves as the National Park Service's prototype monitoring park for the Atlantic and Gulf Coast biogeographic region.

CACO Water Quality Information: Water resources on Cape Cod include extensive salt marshes, bogs, freshwater marshes, and dune slack ponds, as well as 20 permanently-flooded kettle ponds and 55 documented seasonally-flooded wetlands. Salt water marsh estuaries are a primary feature of CACO, but almost all of the estuarine salt marshes within the Seashore have been altered by ditching, dikes, or tide gates. Several freshwater marshes are located in altered river drainages and coastal wetlands that were once salt water systems. Restoration of tidal flow to some of these marshes has recently begun. Contamination of water resources from septic systems, underground oil tanks, landfills, treatment plants, storm water runoff, fertilizers, and atmospheric deposition are major threats to water quality on Cape Cod.

The Massachusetts Department of Environmental Management has designated Pleasant Bay and Wellfleet Harbor as "Areas of Critical Environmental Concern." Pleasant Bay is a transitional area between two biogeographic provinces with extensive salt marsh, tidal flats, and numerous fresh and saltwater ponds. Wellfleet Harbor contains largely unaltered fresh and salt marshes, tidal flats, salt ponds, rivers, bays, and tidal creeks.

The Massachusetts Department of Public Health has issued a fish consumption advisory for all waters within the Cape Cod watershed (including those within CACO) due to mercury contamination. Only a few of the estuarine waters within the boundaries of CACO on the 303(d) list have been assessed for uses such as primary and secondary contact recreation and shell fishing. Many waters only have a fish consumption advisory. Wellfleet Harbor is 303(d) listed due to pathogens and non-support of shell fishing. Also, parts of its adjacent tributaries (Duck Creek, Herring River, Herring Pond, the Pamet River, and Provincetown Harbor) are listed and either partially support or do not support shell fishing due to pathogens. Recently, acidity and metals have been added as impairments for the Herring River.

The Massachusetts Department of Environmental Management has classified waters in and adjacent (within 1,000 feet seaward of mean low water) to CACO as "Outstanding Resource Waters (ORW)." Some of these waters are also covered by the fish consumption advisory. Some of the ORW within Wellfleet Harbor (Duck Creek, Drummer Cove, and upper portions of Hatches Harbor and Blackfish Creek) also are listed by the Cape Cod Commission as having degraded water quality. Two of the water bodies listed as ORW (Herring River and Herring Pond) are also listed on the 303(d) list.

Six of the twenty freshwater ponds within CACO are listed as impaired; however, only Ryder Pond has been assessed for designated uses. Ryder Pond is impaired by nutrients, organic enrichment, and low dissolved oxygen from unknown sources. It supports aquatic life and primary and secondary contact recreation, but other designated uses have not been assessed. It is likely that other ponds may be similarly impaired. The fish consumption advisory also applies to all CACO freshwater ponds.

Colonial National Historical Park (COLO) The 3,740 hectares of COLO, comprised of Yorktown, Colonial Parkway, Jamestown Island, and Colonial Williamsburg (which is managed by the Association for Protection of Virginia Antiquities) are within the coastal plain of Tidewater Virginia. Most of the park extends along either the York or James Rivers, two of the largest rivers contiguous to the western shore of the Chesapeake Bay. Numerous wetlands and waterways and mixed pine and hardwood forests cover most of the park, providing habitat for a large variety of birds, fish, mammals, and aquatic and terrestrial invertebrates typical of the mid-Atlantic Coastal Plain. The Yorktown unit is characterized by sandy/gravely shore in an urban setting. The Jamestown unit occupies all of Jamestown Island on the northeast bank of the lower James River, is low in elevation, and dominated by wetlands and tidal creeks.

COLO Water Quality Information: A complex Network of streams in the York and James watersheds, with substantial areas of salt and freshwater marshes, intersects park lands. Forested and emergent wetland communities cover approximately 27% of the park. The estuarine habitat in the Yorktown unit is dominated by the lower York River, but the park also abuts a tidal creek estuary to the east, the West Branch of Wormley Creek. The estuarine habitat at Jamestown is dominated by the lower James River on one side, and by Sandy Bay, the Back River, and the Thorofare on the other. The park's estuarine wetlands, in particular the Queen Creek and Back River system, are important fish nursery areas. Also, the federally listed sensitive joint-vetch and bald eagle occur in Back River Marsh. COLO also contains 9 Coastal Plain depression ponds, a rare and threatened seasonal wetland community.

Most of the water bodies in the park have portions of their upstream stretches outside of park boundaries; therefore, their water quality is influenced by activities outside of the park. Potential sources of contaminants include industrial and municipal wastewater discharges, storm water runoff from developed areas, septic leachate, boats, and marinas.

The most common impairments to water quality in COLO are pathogens (e.g. fecal coliform), Virginia Department of Health shellfish restrictions, organic enrichment, and low dissolved oxygen. King and Queen Creeks are impaired by organic enrichment, low dissolved oxygen, pathogens, fecal coliform, sediment and siltation, a VDH shellfish restriction, and PCBs in fish tissue, sediments, and the water column. Aquatic life, shell fishing, primary contact recreation, and fish consumption are all affected. Powhatan Creek is impaired by fecal coliform, pathogens, and general benthic standard, affecting the designated uses of aquatic support, and primary contact recreation. Mill Creek is impaired by fecal coliform, affecting primary contact recreation. Felgates Creek is impaired by pathogens from non-point sources and has a shellfish restriction. Indian Field Creek also has a shellfish restriction. The James River is impaired by nutrients of an unknown source. The York River is impaired for the general benthic standard, organic enrichment, dissolved oxygen, and nutrients from unknown and natural sources. Overall, an estimated 45% of all wetland areas, primarily tidal wetlands, are affected by 303(d) listed waters.

Fire Island National Seashore (FIIS) is located on a 7,832 hectare barrier island along the southern coast of Long Island, New York. An additional parcel, the William Floyd Estate, is located across from the island on the Long Island mainland. Approximately 51 km long and averaging about 0.5 km in width, the barrier island is bordered by the inlets of Fire Island to the west and Moriches to the east and is separated from Long Island by the Great South and Moriches Bays. Annual visitation to the National Seashore exceeds 1 million, and seventeen private communities with approximately 4,000 homes lie within the administrative boundary of FIIS on the western end of the island. Fire Island is typical of Atlantic barrier islands that grade from a primary dune along the ocean to salt marsh along the bay, and includes an extensive forested area within the more sheltered area of the dunes on the eastern side of the island. This forest and surrounding areas make up the only federally designated wilderness in the state of New York or in the National Parks of the Northeastern United States. The William Floyd Estate is a complex of forests, fields, and maintained landscapes more typical of coastal uplands in the region.

<u>FIIS Water Quality Information</u>- FIIS is on a coastal barrier island; thus, it contains few fresh water bodies. Freshwater collects seasonally in dune depressions, and there are some forested and emergent freshwater wetland areas, but the majority of wetlands within FIIS are coastal, and receive brackish water from the surrounding bays—Great South Bay, Moriches Bay, and South Oyster Bay. In total, wetlands cover fully 25% (630 ha) of FIIS lands. The protection and management of waters adjacent to FIIS are regional priorities. In 1993, the NPS created the South Shore Estuary Reserve (SSER), which encompasses the estuarine waters of FIIS. Also, in 2002 the Nature Conservancy acquired 4,650 hectares along the bottom of Great South Bay adjacent to FIIS.

All coastal Bays adjacent to FIIS are impaired. FIIS is located 88 km from downtown New York City, and lies within the highly urbanized and suburbanized northeast coastal zone. Thus, land use outside of the park is the primary influence on waters within the boundaries of FIIS. The watershed surrounding Great South Bay is "developing," and as a result, non-point source pollution (nutrients, sediment, and coliform bacteria) from storm water runoff are primary impacts to the Bay. Vessel waste discharge and waterfowl also contribute to the bacterial load. Elevated levels of coliform bacteria are responsible for the periodic closures of shell fishing grounds and bathing beaches of Great South Bay. Brown tides are considered a dominant perennial problem in Great South Bay. The watersheds of Moriches Bay and Shinnecock Bay to the east are developed to a lesser extent; however, elevated levels of fecal coliform bacteria from storm water runoff remain and are responsible for the closure of shellfish beds. Sediment, nutrients, waterfowl waste, and fertilizers and pesticides (from agriculture) also degrade the eastern bays' water quality. The Forge River, which is adjacent to the William Floyd Estate, is also impaired by pathogens from urban, storm, and agriculture runoff, resulting in degraded shell fishing.

<u>Gateway National Recreation Area (GATE)</u> contains 10,644 hectares of historic military fortifications and grounds interspersed with coastal upland forests and fields, freshwater ponds, marshes, bays and mudflats. The park is divided into three geographically separate units that constitute some of the largest and most significant natural areas remaining in the metropolitan New York City area. The Jamaica Bay/Breezy Point Unit includes the entire Jamaica Bay estuary, part of Rockaway Inlet, and the western part of the Rockaway barrier beach. The 3,704 hectare Jamaica Bay Wildlife Refuge, within the Jamaica Bay Unit of GATE, is one of the most important urban wildlife refuges in the United States, and is comprised of salt marsh, upland field and woods, several fresh and brackish water ponds and an open expanse of bay and islands. The Staten Island Unit includes shallow estuarine open waters, Great Kills Harbor, sandy beach, maritime forest, salt marsh, mudflats, riparian forest, grassland and shrub thicket, as well as large areas of disturbed common reed marsh. It supports a number of regionally rare and important species. The Sandy Hook Unit separates the Atlantic Ocean from the southern portion of the New York-New Jersey Harbor Estuary and serves as an important transitional boundary. Predominantly marine and anadromous species are concentrated on the outside;

estuarine species, shorebirds and waterfowl are concentrated on the inside; and migratory land birds are concentrated in the interior of the peninsula. It is the only relatively undeveloped barrier beach area on the northern end of the New Jersey, and it provides habitat for a variety of rare species as well as a rare maritime holly forest.

GATE Water Quality Information- The extensive water bodies within GATE consist mostly of bays or harbors and ocean adjacent to the park units. Estuarine salt marshes are the predominant wetland type, but there are also localized freshwater wetlands and creeks. A total of 698 hectares (13%) of GATE lands are wetlands. Since most of these wetlands are exposed to estuarine waters, the impairments to these waters also degrade the wetlands.

Jamaica Bay Unit waters are impaired by pathogens, nitrogen, and oxygen demand from combined sewer overflows (CSOs), urban runoff, and municipal wastewater discharge. These impairments preclude bathing and shell fishing in Jamaica Bay. The basins connected to Jamaica Bay (Mill, Paerdegat, Shellbank, and Bergen) are impaired by organic enrichment, low dissolved oxygen, pathogens, and nitrogen caused by storm sewers, urban/storm runoff, CSOs, municipal wastewater discharge, and private systems. In these basins, fish propagation and bathing are either impaired or precluded. Hendrix Creek, which also feeds into Jamaica Bay, is impaired by pathogens, oxygen demand, and nitrogen from CSOs and urban/storm runoff, which disturbs fish propagation. Pesticides and chlordane contamination, from urban runoff and sediments, are a problem in Ridder's Pond, impairing fish consumption. East Rockaway Inlet is impaired by pathogens from urban/storm runoff which impairs shell fishing. Fish propagation is precluded in Coney Island Creek due to low dissolved oxygen, pathogens and organic enrichment from CSOs, urban runoff, and on site wastewater treatment systems.

In Lower New York Bay, which borders the Staten Island Unit, consumption of migratory fish species is impaired due to PCBs and pathogens from CSOs. Shell fishing is prohibited in the Staten Island Unit, and only partially supported in the Sandy Hook Unit due to fecal coliform, low dissolved oxygen, chromium, copper, lead, and mercury from unknown sources. In the Sandy Hook Unit, New Jersey allows commercial clam harvest but requires a depuration process. The waters of the Atlantic Ocean adjacent to GATE (King's County) are impaired by pathogens from CSOs, which degrade shell fishing.

George Washington Birthplace National Monument (GEWA) is located in rural Tidewater Virginia, and commemorates the birthplace of George Washington. The park consists of 220 hectares of fairly flat terrain typical of the coastal plain, along the tidal reaches of the Potomac River. Three small sub-basins drain into the Potomac at GEWA. These are Pope's Creek, Bridges Creek, and Digwood and Longwood Swamps. Pope's Creek and other marshes within the park experience significant sea water mixing and support crabs, jellyfish, oysters and other marine organisms. In addition to fresh and saltwater marshes and swamps, natural resources in the park include mixed conifer/hardwood forests, loblolly plantations, and open fields.

GEWA Water Quality Information- The major water bodies in and around GEWA are the Potomac River at the park's boundary and Pope's Creek and associated tidal wetlands within the park. Pope's Creek has a Virginia Department of Health shellfish restriction and is impaired by fecal coliform and pathogens resulting from point and non-point sources. It partially supports shell fishing, crabbing, and primary contact recreation. Nevertheless, sediment contaminant studies indicate that Pope's Creek is among the most pristine creeks in the Chesapeake. Thus, this site has been used as a reference location for numerous studies considering the effects of agricultural runoff on receiving waters and their geochemistry. The Potomac River is impaired by organic enrichment, low dissolved oxygen, suspended sediment, and pathogens resulting from enrichment, natural, and non-point sources. The Potomac River also has a fish consumption advisory in effect. Erosion of the banks of the Potomac is severe and represents a significant threat to GEWA.

Sagamore Hill National Historic Site (SAHI) was the home of Theodore Roosevelt, located on the peninsula of Cove Neck, Long Island, New York. The park consists of 35 hectares that remain from a larger purchase of farmlands in 1883 by Roosevelt. Lawn and field areas near the residence are intact, but most former farmlands have been replaced by an oak-tulip tree forest that slopes down to the four hectare Eel Creek salt marsh on Cold Spring Harbor. In the early 1970's, Congress declared the easternmost forested and salt marsh area of the park a "Natural Environmental Study Area."

SAHI Water Quality Information- Cold Spring Harbor is the only listed water body adjacent to SAHI. The impairments to Cold Spring Harbor are pathogens and PCBs in migratory fish species from urban and storm runoff. Shell fishing and fish consumption are not supported. Dissolved oxygen appears to be a problem--Friends of the Bay (FOB) monitoring, during the summer of 2000, revealed dissolved oxygen concentrations that did not meet the New York State minimum standard suitable for primary contact recreation (swimming).

One small (1.5 ha) salt marsh wetland, fed by the tidal Eel Creek, receives water from Cold Spring Harbor, and thus is probably influenced by the same impairments. Any land use directly impacting this salt marsh would be primarily from the park itself and a few large neighboring estates.

Thomas Stone National Historic Site (THST), located about 32 km south of Washington D.C, commemorates the life, home (Habre-de-Venture) and culture of Thomas Stone, one of the signers of the Declaration of Independence. The park contains 130 hectares of hilly lands that drain into the Hoghole Run, which flows into Port Tobacco Creek south of the park boundary. Natural resources in the park include wetlands, mixed forests and fields. The NPS has conducted few historic natural resource inventories at THST, and current Inventory and Monitoring program efforts are beginning to address large gaps in knowledge about the existing park resources. For example, in 2001, a vegetation inventory and mapping project resulted in the discovery of a new species of sedge (genus *Carex*).

THST Water Quality Information- There are no known vegetated wetlands in the park, and only a few small unnamed ponds and streams, none of which are listed as assessed or impaired. The Port Tobacco River, approximately 1.5 km from the park, is impaired by nutrients from non-point and natural sources, but the non-tidal portion of the river is not 303(d) listed, and no designated uses are impaired for this portion of the river. The Maryland Clean Water Action Plan lists Port Tobacco River watershed as a Category 1 and a Category 3 watershed. It defines Category 1 watersheds as those watersheds not meeting clean water and other natural resource goals, and in need of restoration. Category 3 watersheds are pristine or sensitive watersheds that are in need of extra protection.

1.8 Identification of Critical Scientific and Management Issues for NCBN Parks

Preliminary Identification of Issues of Critical Concern to Northeast Coastal Parks

Before the establishment of funding for the NCBN through the Natural Resource Challenge in 2000, the Northeast Field Area of the National Park Service began to develop a strategy for the long-term protection of natural resources and ecosystems in the region's parks. During the 1990s, both USGS and NPS workshops and symposia were held to discuss the need for ecological monitoring in these parks. Although these workshops included parks outside the more recently established Northeast Coastal and Barrier Network, a number of the Network parks participated.

One of the first planning workshops was held in September 1997--a two-day, inventory and monitoring workshop titled *Developing a Conceptual Design for a Multi-park, Long-term Monitoring Program in the Northeast Field Area, National Park S*ervice. Ten parks participated, including four NCBN parks (ASIS, FIIS, GATE and CACO). The purpose of this workshop was to develop a Northeast field area-wide ecological monitoring strategy.

Prior to this workshop, each participating park was asked to develop a "laundry list" of natural resource related management issues for discussion. Although many issues emerged, the following issues were common to all four participating NCBN parks:

- Adjacent land development
- Accelerated estuarine nutrient enrichment
- Increasing visitor use and recreational impacts
- Shoreline change
- Rare species-protection
- Water quality
- Exotic species impacts

In 1999, as part of the USGS Patuxent Annual Science Meeting, a symposium was organized called *Coastal Issues and Information Needs*. Internationally recognized leaders in coastal ecology joined forces with DOI coastal land and resource managers to identify key scientific issues, information gaps, and long-term data needs relevant to coastal resource management. As in the 1997 workshop, the management issues identified during this meeting were similar across the coastal parks and included adjacent land development, estuarine water quality and nutrient enrichment, increasing visitor and recreational use and their impacts, shoreline erosion, and exotic species (see Appendix 1.7, *Steering Committee Report_Sep 1999*).

In February 2000, another workshop was held in association with Patuxent, titled *Developing a Scientific Basis for Integrated Long-Term Monitoring of Atlantic Coastal Parks and Refuges*. The workshop objectives included identifying indicators for long-term monitoring that provide quantitative information on coastal ecosystem functions, and identifying threshold values for coastal ecosystem indicators that denote sustainable vs. degraded systems (see Appendix 1.8, *Steering Committee Report_Sep 2000*).

The lack of funding prior to the NPS Natural Resource Challenge limited the implementation of the plans and ideas discussed at these symposia and workshops. However, in 2000, after funding became available for the Inventory and Monitoring Program, the NCBN was significantly ahead in designing a long-term monitoring program due to the previous work done in the region. It had identified important ecosystems and issues, and it had prioritized common issues for monitoring in these parks, specifically shoreline change, estuarine nutrient enrichment, and visitor impacts.

Establishment of the Network and Identification of Issues Specific to NCBN Parks

In the fall of 1999, the administrative and operational organization of the Northeast Coastal and Barrier Network initiated a steering committee and board of directors. The NCBN summarized existing data relating to its parks and planned a Network Vital Signs Scoping Workshop. It established the NCBN Technical Steering Committee to advise and assist in decision making regarding the development and implementation of a monitoring strategy, hiring of Network staff, budgeting and scheduling. Members of the committee were nominated by park staff, the regional I&M coordinator and regional chief scientists. Those selected include scientists familiar with Northeast coastal park issues or those who have been involved with or implemented research pertaining to coastal ecosystem monitoring.

The NCBN established a Board of Directors to help manage and oversee the monitoring program. The Board includes the seven superintendents (THST and GEWA share a superintendent) from the NCBN parks, two chief scientists from the region, the Regional I&M Coordinator, and the Network I&M Coordinator. It meets at least once each year to assess the monitoring program's progress, quality control, and spending of Network funds. It works closely with the Network Data Manager and the Technical Steering Committee and is consulted before the hiring of Network personnel. The Board, also, assists in developing strategies and procedures for leveraging Network funds and personnel to best accomplish inventory, monitoring, and other natural resource needs of Network parks. Board members help the Network acquire additional financial support, and facilitate a cooperative interaction with other governmental agencies, organizations, and individuals.

In 1999, the "Conceptual Framework for the Development of Long-term Monitoring Protocols at Cape Cod National Seashore" (CACO) was completed (Roman and Barrett 1999; See see Appendix 1.7, *Steering Committee Report_Sep 1999*), and the Technical Steering Committee proposed that it provide initial structure for the development of the NCBN monitoring program. Development of the CACO long-term ecological monitoring program has been a collaborative effort primarily between U.S. Geological Survey (USGS) and NPS. (The USGS provided most of the funding for development of a conceptual framework for the CACO program and for protocol development. However, the CACO began receiving funding specifically for the long-term monitoring program in 1997.) In 1999, CACO was charged with developing and refining long-term monitoring protocols that could be used by other Atlantic and Gulf Coast parks.

Once the NCBN was established and its 8 parks identified, it sent questionnaires to each Park resource manager and superintendent. Table 1.3 shows the scientific and management issues of concern to natural resource stewardship in NCBN parks, based on these questionnaires, Park GMPs and RMPs, Park enabling legislation, and the NPS and USGS workshops mentioned earlier.

Table 1.3 Critical Scientific and Management Issues of the Northeast Coastal and Barrier Network Parks

ISSUE	CACO	FIIS	SAHI	GATE	ASIS	THST	GEWA	COLO
I. Altered Coastal Processes								
Accelerated rates of erosion due to recreational impacts dredging/deposition of spoil	X			X				X
Sea level rise	X	X		X	X			X
Shoreline Change	X	X		X	X		X	X
Inlet migration	X			X				
Changes in lateral sand transport due to dredging and groins		X		X	X			
Impacts on biota due to dredging of channels/inlets		X		X	X			
Dune habitat characterization							X	
Altered coastal processes impacts on early successional, disturbance driven beach habitat and associated species				X	X			
II. Visitor/Recreational Activity Impacts								
Numerous social trails/trampling of vegetation/mountain bike trails	X	X	X	X			X	X
Jet Skis	X	X		X			X	
Pets off leash/hunting dogs	X	X		X			X	
Releasing non-native pheasants for hunting	X							
Recreational trampling of kettle pond	X							
Visitor impacts/activities on rare species		X		X	X		X	X
Visitor impacts on other plant or animal species		X		X	X		X	X
Recreational impacts on early successional, disturbance driven beach habitat and associated plant/animal species	X	X		X	X		X	
Recreational impacts on bluffs	X						X	X
Off-road vehicle use in park		X		X	X		X	
Increased human activity/disturbance within park due to increased residential development adjacent to park	X	X		X	X			X
III. Water Quality								
Water Quality Within Park								
Identification and assessment of water quality issues	X			X		X	X	
Water quality due to adjacent land use	X	X	X	X	X	X	X	X
Due to Residential development	X		X	X	X	X		X
Due to Urban development				X			X	X

ISSUE	CACO	FIIS	SAHI	GATE	ASIS	THST	GEWA	COLO
Due to Agricultural development					X	X	X	X
Groundwater								
Groundwater withdrawal from residential development and impacts to wetland vegetation and animal life	X		X	X				
Assess potential groundwater contamination				X		X		X
Impacts to groundwater from landfill leachates	X			X				X
Nutrient Enrichment								
Septic inputs from residential development within or adjacent to park	X	X	X	X	X		X	X
Industrial effluent				X				
Cultural nutrient enrichment of Kettle Ponds and Salt Marsh	X			X				
Freshwater and Coastal Marine Eutrophication	X			X	X			
Estuarine Water Quality								
Adjacent land use changes affects on estuarine water quality	X	X	X	X	X		X	X
Urban		X		X				X
Residential	X	X	X	X	X		X	X
Agricultural					X		X	X
Decline (loss) of submerged aquatic vegetation (SAV)		X		X	X		X	X
Impacts on aquatic resources from channel and marina dredging and pollution from community marinas unknown		X		X				
Changes in associated biotic communities		X	X	X	X		X	
Impact of landfill leachate	X			X				
Impacts on estuarine water quality due to shoreline erosion				X			X	X
IV. Vertebrates, Plants and Their Associated Communities								
Wildlife Management								
Factors contributing to decline in species ?abundance	X	X		X				
Lack of status and distribution data on formerly common species	X	X		X				
Lack of baseline studies for most species	X	X		X		X	X	X
Habitat impacts from deer population		X			X	X	X	X
Habitat impacts from woodchuck population							X	X
Neotropical migrant use of park habitats		X	X	X		X	X	X
Bird aircraft collisions				X				
Beach nesting bird predators / sources of disturbance		X		X	X			
Habitat management for grassland birds				X		X	X	X
Preservation of Native spp. Biodiversity	X	X	X	X		X	X	
Rare, Threatened and Endangered Species Protection and restoration (Vertebrates)	X	X		X	X	X	X	X
Document species composition, distribution, abundance and any rare species		X	X	X	X	X	X	
Impacts of hunting and power line right of way on species						X	X	
Impacts of Residential/Urban development within and adjacent to park								
Impacts on vertebrate populations due to increases in roadkill	X			X				X
Impacts on vertebrate populations by habitat fragmentation	X	X	X	X				X
Impacts on native vertebrate populations due to pet predation	X	X		X				X
Impacts of increased human disturbance on wildlife		X	X	X	X	X		X
Exotic/Invasive Species								
Plants	X	X	X	X	X	X	X	X

ISSUE	CACO	FIIS	SAHI	GATE	ASIS	THST	GEWA	COLO
Animals		X		X	X	X	X	X
Rare/sensitive habitats at risk from exotic spp		X		X	X		X	X
Lack of info on impacts to distribution, abundance of native biota and physical processes	X	X	X	X	X	X	X	X
Loss of grassland/heathland habitats and associated wildlife	X			X		X	X	
Habitat Loss								
Salt Marsh loss	X	X		X			X	
Maritime forest and grassland loss				X				
Habitat Restoration								
Historic diking of Salt Marshes and need for restoration	X	X			X			
Best action plans for saltmarsh restoration		X		X	X			
Estuary restoration				X			X	
Forest				X		X	X	
Field			X	X		X	X	X
Resource Extraction/Harvest								
Horseshoe crab/crab extraction	X	X		X			X	X
Shell fishing Impacts	X	X		X	X			X
Hunting Impacts	X	X				X	X	X
Fishing Impacts	X	X		X	X		X	X
Fruits and Fungi	X			X				X
Vascular plants								
Document species composition, distribution, abundance of rare species		X		X		X	X	
Native grass species reintroduction				X		X	X	X
Impacts of landscape alteration by Europeans over 4 centuries	X	X		X		X	X	X
Loss of plant species due to shoreline erosion		X		X			X	
Protection of RTE listed plant species			X	X		X	X	
Habitat health-forests, freshwater marsh, riparian zones and salt marsh		X		X		X	X	X
V. Other								
Air pollution								
Lack of knowledge regarding air quality		X	X	X		X	X	
No particulate and SO2 monitoring	X			X		X	X	X
Impacts to Aesthetic Resources								
Structures, bulkheads, groins, beach scraping and barrier islands		X		X				
Human Health								
Mosquito management	X	X		X	X	X	X	X
Open Water Marsh Management usefulness in decreasing mosquito populations		X						
Rabies vectors				X	X			

1.9 Natural Resources Significant to enabling Legislation and Legal Mandates

To identify significant natural resources, the NCBN reviewed each park's enabling legislation and planning documents. Table 1.2 shows a list of natural resources summarized from each park's enabling legislation, as well as natural resources significant to other federal legal mandates. Four Network parks—ASIS, CACO, FIIS, and GATE—specifically note natural resources in the enabling legislation. Although natural resources are not mentioned in the enabling legislation of other parks, certain resources are significant because of key historic landscapes (e.g., field, forest, salt marsh, beach, wetland, and rivers). Also, parks such as GEWA and Sagamore SAHI are concerned with preserving the natural viewshed, or vistas, from Park historic buildings.

Every Government entity, including the NPS and each of its National Parks, is required by the Government Performance and Results Act of 1993 (GPRA) to produce a 5 year Strategic Plan with measurable goals. Table 1.4 shows the goals relative to natural resources from the Strategic Plans, 2001-2005. In 2004, all agencies and services within the Department of the Interior, including the NPS, merged their goals into a unified set of Department goals. Since the current Strategic Plans were written using the original NPS-specific goals, Table 1.3 shows both the NPS and Department goals under GPRA.

ASIS, CACO, FIIS and GATE have specific protection responsibilities under Executive Order 13158-Marine Protected Areas (MPA). This order defines an MPA as "any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein" (Federal Register 2000). MPAs are management tools to help protect, maintain, and restore natural and cultural resources in coastal and marine waters. They have been used effectively both nationally and internationally to conserve biodiversity, manage natural resources, protect endangered species, reduce user conflicts, provide educational and research opportunities, and enhance commercial and recreational activities (Salm *et al*. 2000).

Five parks in the NCBN have federally listed species, including both plants and animals. These include beach nesting populations of the federally threatened piping plover at ASIS, CACO, FIIS, and GATE; threatened bald eagles at COLO, ASIS, and GEWA; and the threatened sea beach amaranth at ASIS, FIIS, and GATE. CACO's 17 federally listed species are the most of any Network park.

Table 1.3 Legislative guidance for Vital Signs monitoring in the Northeast Coastal and Barrier Network parks

Park	Natural Resources identified in Park Enabling Legislation	Natural Resources Significant to Other Federal Legal Mandates
Assateague National Seashore	Assateague Island and adjacent waters and small marsh islands. Conservation of natural features contributing to public enjoyment. Hunting, fishing, and shell fishing permitted in accordance with State laws, provided that Federal laws regulating migratory waterfowl are not added to or limited. The Secretaries of the Interior and Army shall cooperate in the study of plans for beach erosion control and hurricane protection.	**Endangered Species Act -** Piping plover (Listed Threatened [LT]), Bald eagle (LT) sea beach amaranth (LT), loggerhead sea turtle (LT). **Marine Mammal Protection Act - Various species. Executive Order 13158 - Marine Protected Areas.**
Cape Cod National Seashore	Lands and waters out to a quarter of a mile offshore. No development or plan incompatible with the preservation of the unique flora and fauna and physiographic conditions shall be undertaken. Hunting and fishing permitted under State and Federal jurisdiction, and shell fishing permitted under State and town jurisdiction.	**Endangered Species Act** - 17 listed animal species, including piping plover. **Marine Mammal Protection Act** - Various species. **Executive Order 13158 - Marine Protected Areas.**
Colonial National Historic Park	None Identified	**Endangered Species Act** - Bald eagle (LT), sensitive joint-vetch (LT), Small whorled pogonia (LT).
Fire Island National Seashore	Undeveloped beaches, dunes, and other natural features. Sunken Forest shall be preserved from bay to ocean. No development shall be undertaken between Brookhaven town park at Davis Park and Smith Point County Park which would be incompatible with the preservation of the flora and fauna or the physiographic conditions (see wilderness designation, next cell). Hunting, fishing and shell fishing permitted in accordance with State and Federal laws. Shore erosion or beach protection measures shall be exercised with a plan acceptable to the Secretaries of Interior and Army.	**Endangered Species Act -** Piping plover (LT), Roseate tern (Listed Endangered [LE]), sea beach amaranth (LT). **Marine Mammal Protection Act - Various species. Public Law 96-585,** December 23, 1980 designated 1363 acres of parkland, located between Smith Point and Watch Hill as a National Wilderness area.
Gateway National Recreation Area	Lands, waters, marshes and submerged lands, including all islands, marshes, hassocks, submerged lands and waters of Jamaica Bay and Floyd Bennett Field. The Jamaica Bay Unit shall be administered and protected with the primary aim of conserving the natural resources, fish, and wildlife. Hunting, fishing, shell fishing, trapping, and taking of specimens are permitted according to Federal and State laws.	**Endangered Species Act -** Piping plover (LT), sea beach amaranth (LT); Roseate tern (LE), Peregrine Falcon (Delisted Taxon, Recovered, Being Monitored First Five Years). **Executive Order 13158 - Marine Protected Areas.**
George Washington Birthplace National Monument	None Identified	**Endangered Species Act** - Bald Eagle (LT)
Sagamore Hill National Historic Site	None Identified	None Identified
Thomas Stone National Monument	None Identified	None Identified

Table 1.4 Government Performance and Results Act (GPRA) Goals Related to Inventory and Monitoring Program in Northeast Coastal and Barrier Network Parks

Note: GPRA goals as reported in Strategic Plans for 2001-2005; target date for all goals is September 30, 2005. All NPS GPRA goals have been integrated into Department of the Interior (DOI) GPRA goals, and will be converted for 2006-2010 Strategic Plans.

NPS GPRA GOAL	DOI GPRA GOAL	National Park Service	Assateague Island National Seashore	Cape Cod National Seashore	Colonial National Historic Park	Fire Island National Seashore
Long-Term Goal Ia1A	**BG NK-PIM**	10.1% of targeted parklands disturbed development or agriculture, as of 1999 (22,500 of 222,300 acres), are restored	100% of Assateague's estimated average annual sediment deficit caused the Ocean City inlet jetties (145 cubic meters) is being passed to Assateague Island on an annual basis.	10% of targeted lands disturbed prior development or agricultural uses are restored.		
Long-Term Goal Ia1B	**PEM .2.004**	Exotic vegetation on 6.3% of targeted acres of parkland (167,500 of 2,656,700 acres) is contained	(1) the ASIS feral horse population is reduced from its FY1999 size of 168 5 horses. (2) the number of Sika deer killed during the ASIS public hunting season is maintained at the FY1999 level (~100).	6.3% of the targeted acres impacted exotic vegetation, as of 2002 are contained.	Exotic vegetation is contained on 60 (2%) of 3,700 acres of park lands identified September 30, 1999 as impacted exotic vegetation.	
Long-Term Goal Ia2A	**BG**	19% of the 1999 identified park populations (84 of 442) of federally-listed threatened and endangered species with critical habitat on park lands or requiring NPS recovery actions have an improved status.	1 (50%) of ASIS's 2 identified populations of federally listed threatened and endangered species requiring NPS recovery actions as of 1999, have an improved status.	One of the two identified populations of federally listed threatened and endangered species with no critical habitat at CACO and not requiring NPS recovery actions, as of 1999, (i.e. piping plover) has improved status.		

NPS GPRA GOAL	DOI GPRA GOAL	National Park Service	Assateague Island National Seashore	Cape Cod National Seashore	Colonial National Historic Park	Fire Island National Seashore
Long-Term Goal Ia2B	**BG**	An additional 18.1% of the 1999 identified park populations (80 of 442) of **federally-listed threatened and endangered species** with critical habitat on park lands or requiring NPS recovery actions have stable populations.	1 (50%) of ASIS's 2 identified populations of federally listed threatened and endangered species with critical habitat on park lands and/or requiring NPS recovery actions as of FY1999, have a stable status.		100% of the 1997 identified park populations [1 of 1] of federally listed species not having critical habitat on COLO lands and not requiring NPS recovery actions have stable populations.	
Long-Term Goal Ia2X	**BG**	[Park-determined percentage of] populations of plant and animal **species of special concern** (e.g., state listed threatened or endangered species, endemic or indicator species or native species classified as pests) are at scientifically acceptable levels.		(Ia2D) one of the two identified populations of federally listed threatened and endangered species not having critical habitat at CACO and not requiring NPS recovery actions as of 1999, (i.e., roseate tern) has an unknown status.		
Long-Term Goal 1a3	**BG**	**Air quality** in 70% of reporting park areas has remained stable or improved.		Air quality at CACO has remained stable or improved.		
Long-Term Goal Ia4	**PEM .1.008**	85% of park units will have **unimpaired water quality**	the oceanic and estuarine surface waters of ASIS have unimpaired water quality.	CACO will have unimpaired water quality.	COLO does not have unimpaired water quality.	FIIS has unimpaired water quality.

NPS GPRA GOAL	DOI GPRA GOAL	National Park Service	Assateague Island National Seashore	Cape Cod National Seashore	Colonial National Historic Park	Fire Island National Seashore
Long-Term Goal Ia6	**BG**	73.4% of preservation and protection standards for park museum collections are met	57 (75%) of 76 applicable preservation and protection standards for ASIS's museum collections are met.		2005, 77% (675 of 873) of preservation and protection standards for park museum collections are met.	74% of 221 applicable preservation and protection standards for FIIS's museum collection are met (19 deficiencies corrected).
Long-Term Goal Ib1		acquire or develop 87% (2,203) of the 2,527 outstanding data sets identified in 1999 of basic natural resource inventories for all parks	datasets are developed describing the status of 5 species of special concern at ASIS.		11 of 12 (92%) of the park's primary natural resource inventories identified in a Resource Management Plan and General Management Plan are completed.	FIIS has acquired 80% of 15 natural resource inventories (12 total data sets).
Long-Term Goal Ib3	**BG**	80% of 265 parks with significant natural resources have identified their vital signs for natural resource monitoring	ASIS has identified its "vital signs" for natural resource monitoring.	CACO has identified its vital signs for natural resource monitoring.	The park has identified its vital signs for natural resource monitoring.	FIIS has identified its vital signs for natural resource monitoring.
Long-Term Goal Ib4	**PEM .3.005**	**Geological processes** in 53 parks (20% of 265 parks) are inventoried and human influences that affect those processes are identified.	1 (100%) of 1 geological processes of special concern at ASIS are actively studied and monitored for needed mitigation.			

NPS GPRA GOAL	DOI GPRA GOAL	Gateway National Recreation Area	George Washington Birthplace National Monument	Sagamore Hill National Historic Site	Thomas Stone National Historic Site
Long-Term Goal Ia1A	**BG NK-PIM**	10 (10%) of 100 acres of Gateway's lands, disturbed by prior development or agricultural use and targeted are restored.			
Long-Term Goal Ia1B	**PEM .2.004**	13 (6.5%) of 200 acres of GATE's lands impacted exotic vegetation targeted September 30, 1999 are contained.	100% of 10 acres of GEWA's targeted lands impacted exotic species, as of FY1999, are contained.	Exotic vegetation on 6.3% of targeted acres of parkland (167,500 of 2,656,700 acres) is contained.	
Long-Term Goal Ia2A	**BG**	The piping plover and roseate tern, 2 (50%) of GATE's 4 identified populations of federally listed threatened and endangered species with critical habitat on park lands or requiring NPS recovery actions, as of 1999, have improved status. The other 2 species, the tiger beetle and sea beach amaranth, will be inventoried, and their status determined.			
Long-Term Goal 1a2B	**BG**	The tiger beetle, 1 (25%) of GATE's 4 identified populations of federally listed threatened and endangered species with critical habitat on park lands or requiring NPS recovery actions, as of 1999, has a stable status.	1 (100%) of GEWA's 1 identified population of federally listed threatened and endangered species with critical habitat on park lands and/or requiring NPS recovery actions, as of 1999, have a stable status.		
Long-Term Goal Ia4	**PEM .1.008**	GATE's estuarine and ocean waters have impaired water quality.			
NPS GPRA GOAL	**DOI GPRA GOAL**	**Gateway National Recreation Area**	**George Washington Birthplace National Monument**	**Sagamore Hill National Historic Site**	**Thomas Stone National Historic Site**

Long-Term Goal Ia6	**BG**	Museum Collections: 240 (70%) of 344 preservation and protection standards for GATE’s museum collections are met	206 (73.4%) of 281 applicable preservation and protection standards for GEWA museum collections are met.	292 (92.7%) of 315 applicable preservation and protection standards for SAHI’s museum collections are met	7 (73.4%) of 9 applicable preservation and protection standards for THST museum collections are met.
Long-Term Goal Ib1		25 of 100 (25 %) of GATE’s known populations of plant and/or animal species of special concern are inventoried and evaluated for scientifically acceptable levels, and a monitoring program is in place for each species.	Develop 30% of outstanding data sets identified in 1999 of basic natural resource inventories for GEWA.		Develop 30% of outstanding data sets identified in 1999 of basic natural resource inventories for THST.
Long-Term Goal Ib3	**BG**	GATE has identified its vital signs for natural resource monitoring.	GEWA has identified its vital signs for natural resource monitoring.	SAHI will have identified its vital signs for natural resource monitoring	THST has identified its vital signs for natural resource monitoring.

1.10 Natural Resources Identified in Network Park Management Plans

Park planning documents, specifically General Management Plans (GMPs), and Resource Management Plans (RMPs) provide an overview of the most significant park resources and management issues. They also outline goals for future park management. Table 1.3 and Table 1.4 summarize the natural resources and related issues identified by each NCBN park in these plans.

Since Network parks exhibit a high degree of physical and biological similarity, due to their coastal location and similar climatic influences, many of the same ecosystem types occur in the parks. Significant ecosystem types that are the focus of protection or enhancement in planning documents include:

- Shoreline/Barrier Beach and Dune
- Salt marsh
- Estuary
- Coastal Upland
- Freshwater wetlands

Many of the influences on natural resources from the heavily developed and populated northeastern coastal region are similar across Network parks. Thus, the NCBN has identified many of the same management issues across park plans. Natural resource-related issues found in many of the NCBN park planning documents include:

- Water quality
- Coastal water body eutrophication
- Visitor use impacts, including resource consumption
- Shoreline processes/shoreline erosion
- Deer population management
- Protection of rare, threatened and endangered species
- Exotic plants and animals
- Air quality
- Viewsheds
- Woodland preservation

These resources and issues have been well represented throughout the planning process for the NCBN vital signs monitoring program. Each of these primary ecosystem types will be incorporated into the NCBN inventory and monitoring work. Chapter 2 details the conceptual models for each of these ecosystem types. Inclusion of every issue of concern within the NCBN inventory and monitoring program would be impossible. However, inventory work associated with the NCBN will capture information relating to all of the management issues listed earlier, except visitor use, viewsheds, and deer population management. Also, vital signs monitoring projects will directly address water quality and eutrophication, visitor use impacts, and shoreline processes and erosion.

Table 1.5 Summary of Northeast Coastal and Barrier Network Parks General Management Plans

Park	Natural Resources and Natural Resource – Related Goals from General Management Plans
ASIS	**(1982) Resources:** Barrier beach and dune system. Beach grass, shrub thicket, wetland forest, and salt marsh communities. Wetland plants in impoundments. Assateague horse, peregrine falcon, Delmarva fox squirrel, osprey, eastern merlin, Ipswich sparrow, and Atlantic loggerhead turtle. Dynamic physical and ecological processes and natural succession. **Plan Goals:** Management of exotic plants and animals. Assateague horses managed as a desirable feral species. Visitor-operated vehicles limited to certain zones and for certain purposes. Collaborate on implementing a plan to slow, stop, or reverse the shoreward erosion of northern Assateague Island. Protection of habitats of endangered flora and fauna. Maryland upland game hunting will continue. In some areas dune breaks and crossings will be repaired or maintained. Beach recreation, fishing, clamming, crabbing, mussel gathering, canoeing and wildlife observation will be permitted. Back country campsites will be maintained.
CACO	**(1998) Plan Goals**: Engage in cooperative regional efforts to improve air quality. Allow natural shoreline processes to take place unimpeded. Protect ground and surface water quality and quantity, as well as wetlands. Upgrade septic treatment facilities to reduce nitrates. Correct runoff point sources. Develop resource management plans for all kettle ponds. Research and monitor effects of aquaculture on marine resources. Restore the natural hydrography and ecology of estuaries in consultation with affected municipalities (including Herring River salt marsh, Pamet River, and Pilgrim Lake areas). Manage native biotic resources by allowing natural processes to continue unimpeded except where appropriate to selectively manage for native biological diversity or rare species or communities. Utilize fire management to restore or simulate natural role of fire. Develop management plans for heathlands. Restore native habitats and disturbed areas. Develop non-native species management program. Review and permit finfish and aquatic plant aquaculture based on strict conditions. Develop a comprehensive pest management program.
COLO	**(1993) Resources:** Chesapeake Bay, James and York Rivers, and tributaries. Tidal salt water and estuarine wetlands, freshwater wetlands. Coastal plain sediments. Federally listed bald eagle and several state listed flora and fauna species. Hardwood and pine-hardwood forests, salt marsh and freshwater wetland vegetation. Submerged aquatic vegetation. **Plan Goals:** Protect rare, threatened, and endangered species by developing sub-zones within historic zones for protection and management. Protect wetlands and floodplains. Limit disturbance in upland areas. Develop inventory and database of natural resources. Develop an active resource monitoring program. Cooperate with other agencies and landowners to promote resource preservation.
FIIS	**(1977) Resources:** Dune line fringing beach. Freshwater bog habitats. Tidal marshes. Skirted Pine Fire Island Lighthouse tract (salt spray influenced vegetation). Sunken Forest. Maritime forest at Point O'Woods. Old Inlet dunes and marsh. High marsh area south of Hospital Island. Watch Hill interpretive area. Clam pond area coves and marshes. Nesting common tern habitat on John Boyle Island. Tidal marshes, swamps, and ponds on Floyd Estate. **Plan Goals:** Protect natural resources of beaches and dunes, maritime holly forests of the Sunken Forest, and experimental marsh adjacent to Barrett Beach. Maintain water quality of Great South Bay and aquifers underlying Fire Island area. **"Update GMP" PMIS statement[1] (2001) Issues:** Shoreline erosion, including in Otis Pike High Dune Wilderness. Deer population management. Insect borne pathogens including Lyme Disease, Eastern Equine Encephalitis, and West Nile virus. Five rare plant and animal species including plovers and terns. Water quality in Great South Bay.

Table 1.5 (Cont.). Summary of Northeast Coastal and Barrier Network Parks General Management Plans

Park	Natural Resources and Natural Resource – Related Goals from General Management Plans
GATE	**(1979) Resources:** Holly forest at Sandy Hook. High and low salt marshes, primary dunes, freshwater marshes, and beach heather communities. Waterbird nesting sites. **Plan Goals:** Identify, preserve, and provide for visitor appreciation of fish, wildlife, and other natural resources. Protect holly forest at Sandy Hook. Protect wildlife refuge in Jamaica Bay. Improve air and water quality. Minimize air and water pollution in Jamaica Bay. Protect tern nesting sites. Employ habitat management techniques to protect wildlife, including migratory bird and butterfly species. Study *phragmites* role in the marsh ecosystem. Employ biological control of ticks, mosquitoes, green flies etc... wherever possible.
GEWA	**From Statement for Management[2] (1986) Goals:** Secure through research, or other means, adequate information to facilitate information and perpetuation of the Pope's Creek Farm and other historical and natural resources. Preserve...the quality of natural scenes.
SAHI	GMP planning in process.
THST	**(1989, Revision 1996) Resources:** Coastal plain geology and soils. Many springs and three ravines cut by intermittent streams, draining to Hoghole Run. Palustrine non-tidal freshwater wetlands, including farm pond, forested wetland, and emergent wetland. Mixed hardwood and pine forests with regionally representative shrub under story. Oak decline syndrome. Beaver, white-tail deer, and Bluebirds. Gypsy moths. Ticks and Lyme disease. Class 2 air quality area. **Plan Goals:** Manage and protect the natural resources of the site consistent with the need to interpret agrarian lifestyles and re-establish historic landscapes. Provide appropriate wildlife habitat and preserve the existing wooded areas to prevent further erosion of the ravines and streambeds. Improve the quality of surface water that enters Hoghole Run. Restore pond areas to natural and historic condition.

Notes: [1] - Project Management Information System, a database used to track projects throughout the NPS. [2] - Statements for Management are used by the National Park Service to identify the guiding management priorities for parks.

Table 1.6 Summary of Northeast Coastal and Barrier Network Parks Resource Management Plans

Park	Natural Resources Identified in RMP	Natural Resources Related Issues from RMP	NR Related Management Objectives from RMP
ASIS	**(1993)** Freshwater ponds, salt marsh wetlands, tidal mudflats, sea grass beds, and open water habitats. Assateague horse. Sika deer. Tundra peregrine falcon, loggerhead sea turtle, Delmarva fox squirrel, and piping plover. Wintering waterfowl populations, reptiles and amphibians, and marine mollusks. Submerged aquatic vegetation. Marine finfish, shellfish, and benthic invertebrates. Freshwater fish and invertebrates. *Phragmites*.	Artificial dune systems preventing over wash processes. Past development activity. Remnant roadbeds and mosquito control drainage ditches. Disruption of natural coastal processes outside the Seashore's boundaries. Assateague horse herd influence on vegetation. Sika deer competition with the native white-tailed deer. Recreational visitor use impacts on shorebirds, including plovers. Loss of wetlands and submerged habitats. Marine and estuarine impacts from dredging, motor vessel use, fisheries, increased nutrient input, increased surface water runoff, and contamination by toxic elements. Changes in local/regional land use practices. Limited information on algae, liverworts, mosses, lichen, and fungi.	Development of management strategies including fire management, exotic species, ORV use, dune management, adjacent land use, and especially feral horse herd management and island dynamics at the North End. Development of a comprehensive monitoring plan. Restoration of impacted resources, emphasizing species of special concern, mitigation of visitor use and external impacts, and the reversal of past management and land use practices.
CACO	**(1999)** Terrestrial resources include pitch pine/oak forest, heathlands, dunes, coastal plain pond shores and barrier spits. Aquatic resources include sole source aquifer, kettle and dune ponds, streams and rivers, freshwater marshes, sphagnum and cranberry bogs, red maple and white cedar swamps, vernal ponds, brackish impoundments, intertidal salt marshes, mud and sand flats, eelgrass and marine algae beds, rockweed and barnacle communities, and open marine waters. 32 state listed plant species (none are federally listed). 14 federally listed wildlife species and an additional 58 state-listed species. Non-native plant and animal species.	Impacts of development on water quality and quantity. Accelerated rates of freshwater and coastal marine eutrophication. Impacts of recreation on natural resources. Effects of landscape changes since European settlement. Protection and restoration of federal and state listed rare species and communities. Consumptive uses of resources. Air pollution. Sea level rise.	Allow natural shoreline processes to take place unimpeded. Protect ground and surface water quality and quantity. Restore natural hydrography and ecology of estuaries. Manage native biotic resources. Manage special uses affecting wildlife populations and other biotic resources. Engage in cooperative regional efforts to improve air quality. Implement comprehensive and long-term program of ecological monitoring and research.
COLO	(1999) Marine and freshwater wetland habitats, including forested and emergent wetlands, pine, mixed pine - hardwood, and hardwood forests, open fields, freshwater and estuarine rivers, ponds, coastal bluffs and ravines. Yorktown onions. Several national champions' specimen trees. Nine Natural Heritage - listed species (4 plant, 5 animal). Birds, fish, mammals, aquatic invertebrates, plants and	Effects of activities outside Park boundaries on water quality within the park (oil spills, erosion and sedimentation, chemicals). Shoreline erosion and recession. Potential local sources of groundwater contamination from nitrate and ammonia at several sites near Jamestown Island, Williamsburg and Yorktown. .	Development and implementation of invasive species mitigation and vegetation management programs dealing with fields, shorelines and earthworks. Endangered species monitoring. Water and wetlands monitoring. Wildlife inventory work. Biological and physical study of the sinkholes and the geohydrological framework of the Yorktown environs, as part of the larger inventory of the biotic

	wetlands typical of the mid-Atlantic Coastal Plain. Upland and tidal streams as well as freshwater and brackish ponds along Colonial Parkway. A freshwater spring and a small creek at Green Spring plantation. A series of springs and seeps originate on Yorktown Battlefield. Numerous ephemeral ponded sinkholes occur in the Yorktown Battlefield and along the Parkway between Yorktown and College Creek.		and abiotic environment of the Yorktown Battlefield environs. Surface and Ground water analysis and long-term monitoring. Parkwide study of reptiles and amphibians. Cooperative deer population and management research and monitoring studies with adjacent jurisdictions. Design and implement a long-term environmental monitoring program. Flora surveys are needed. Forestry and landscape management.

Table 1.6 (Cont.) Summary of Northeast Coastal and Barrier Network Parks Resource Management Plans

Park	Natural Resources Identified in RMP	Natural Resources Related Issues from RMP	NR Related Management Objectives from RMP
FIIS	**(1998)** Tidal ponds at Floyd Estate. Fresh and brackish water ponds. Category 2 air quality region. Primary dune, swale, secondary dune, maritime forest, fresh water marsh/bogs, and salt-water marsh vegetation communities. Beach amaranth. Piping plover, gulls, terns, osprey, northeast beach tiger beetle, and eastern mud turtle. Pest species - Norway rat, wood boring insects, gypsy moth, mosquitoes.	Encroachment into Park lands. Water quality in Great South Bay, ocean bathing beaches, and ocean and bayside beaches. No method of obtaining pollution information. Weather stations require funding for maintenance to be used. Wildlife distribution and impacts. Dominance of exotic species on Fire Island is not being studied sufficiently. *Phragmites* continues to increase in the Wilderness area marsh. Impacts of wildlife browsing and plant dominance on Sunken forest plant communities. Need for biological technicians with a natural resource background for inventory and monitoring. Lyme disease. Turbidity impacts to flora and fauna along the bayside shore. Pollutant impacts to the bayside ecosystem from marinas. Impacts of home bulkheading and scraping on dunes. Aircraft overflight noise in wilderness area.	Survey, determine, and mark Seashore boundaries. Complete IPM and Fire Management Plans. Control autumn olive and tree of heaven at Floyd Estate. Survey recreational and commercial fishing. Clarify the condition and impacts of fresh water ponds. Implement sustained geologic resources monitoring program for dunes. Develop an Inventory and Monitoring program for park vegetation. Plan habitat restoration activities following protection of vehicle free areas and rare species research. Monitor human disturbance of rare species habitat and mitigate. Monitor visibility by photo-documentation.
GATE	**(1992)** Ecology Village Pine Forest. Jamaica Bay ponds. Staten Island breeding birds, aquatic invertebrates and freshwater wetlands. Sandy Hook ponds. Great Kills salt marsh peat. Rare plants including seabeach amaranth and seabeach knotweed. Osprey. Cavity nesting birds. Grassland bird habitat. Swamp white oak forest. Exotic plants.	Jamaica Bay estuarine and terrestrial impacts from landfill contaminants. Vegetation impacts by vehicles.	None identified.

GEWA	**(2000)** Open fields and forests. Historic trees approaching 200 years in age. Fresh water and brackish marshes, estuaries, three freshwater ponds. Beach and dune assemblages. Hydric and non-hydric soils. Bald eagles. Wintering waterfowl. White-tail deer. Pope's and Bridge's Creeks. Gypsy moth. *Phragmites*.	Air quality threats are likely to increase. Oil leases are potential water quality threat. Concern about aquifer water quantity.	Manage habitats to achieve greatest health and diversity and to allow for the reintroduction of native species that should be present, including managing for non-native species.
SAHI	**(1992)** Open fields. Woodlands. Two glacial ponds. Marsh. Beach.	None identified.	Develop baseline information on natural resources.
THST	**(1992)** Wildlife and plants typical of a Southern Maryland wooded area. Eastern bluebirds. Several small streams emptying into Hoghole Run. One spring-fed pond.	None identified.	Maintain wildlife habitat by preserving the existing wooded areas to prevent further erosion of the ravines and streambeds.

1.11 Identifying Candidate Vital Signs

The NCBN, guided by the Technical Steering Committee, has facilitated a multi-step process to identify and select vital signs and the indicators needed to monitor them. To move from first steps to a final monitoring program, the NCBN conducted a series of meetings and workshops, which resulted in reports to complete the selection of monitoring projects and each project's candidate vital signs. This process is summarized below and in Figure 1.2. Also, see Chapter 3 for a description of the prioritization and selection of final vital signs.

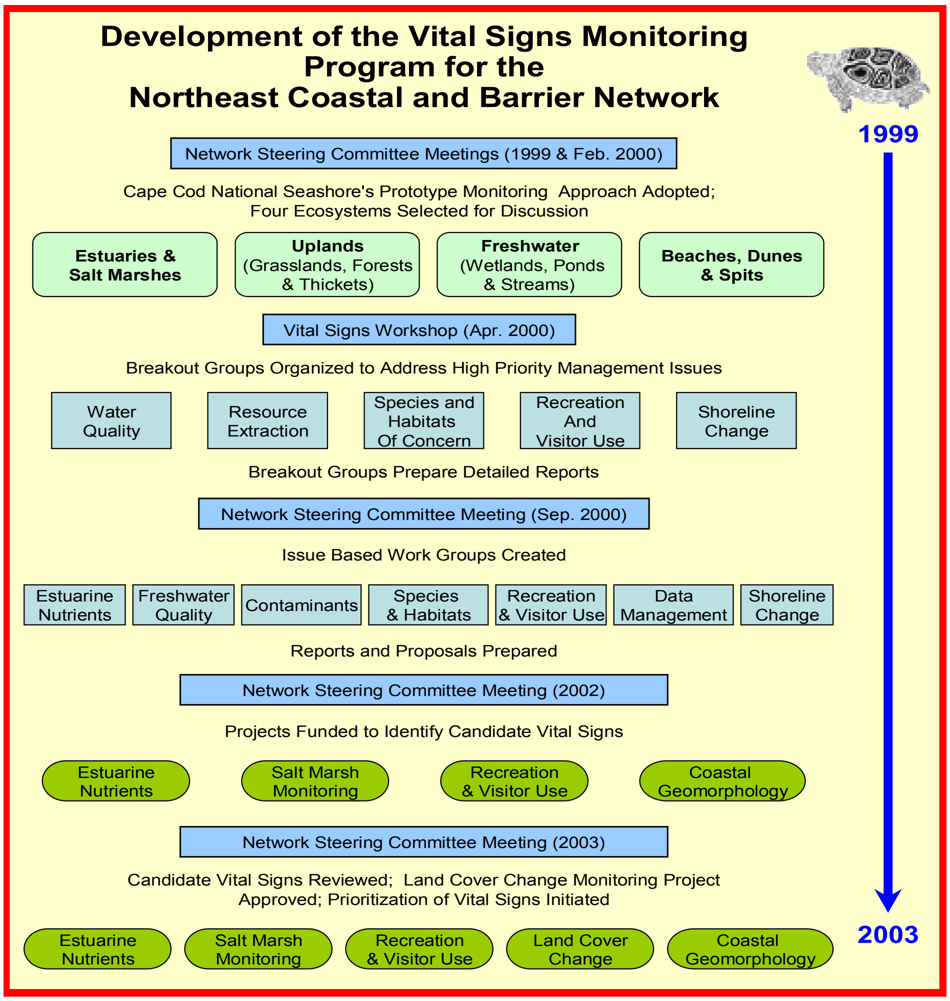

Figure 1.2 Schematic Diagram of the Development of the Vital Signs Monitoring Program for the Northeast Coastal and Barrier Network

1.12 The Network Scoping Workshop

In April 2000, a NCBN Vital Signs Scoping Workshop convened at Gateway NRA. The NCBN invited regional coastal scientists from universities and other agencies, staff from the National Inventory and Monitoring program, the NCBN, Cape Cod NS, and other Network parks. Workshop participants discussed the key management issues identified by the Technical Steering Committee and developed a preliminary list of candidate vital signs that could be further tested for inclusion in the Network vital signs monitoring program. The forty-one people who attended were divided into five workgroups based on broad management issues (shoreline change, water quality, species and habitats of concern, resource extraction, and recreation and visitor use). Each workgroup developed preliminary monitoring questions, and identified candidate vital signs. The final workshop report includes a set of workgroup reports (See Appendix 1.9, *Vital Signs Workshop Report_Apr 2000*).

1.12.1 Issue-based Working Groups

In September 2000, the Network Steering Committee met to review the scoping workshop report and plan the next steps for developing the NCBN vital signs monitoring program (See Appendix 1.8, *Steering Committee Report_Sep 2000*). The Committee decided that the scoping workshop was successful in developing "laundry lists" of vital signs for the Network, but agreed that smaller working groups were needed to begin fine tuning the monitoring questions and candidate vital signs developed by the scoping workshop workgroups. The Committee recommended the formation of seven issues-based workgroups:

1. Shoreline Change
2. Estuarine Nutrient enrichment
3. Freshwater Quality
4. Contaminants
5. Recreation and Visitor Use
6. Animal and Plant Species and Habitats of Special Concern
7. Data management

Approximately five people were assigned to each workgroup under the direction of at least one Steering Committee member. Each work group reviewed existing Cape Cod protocols and scoping workgroup reports, defined and prioritized monitoring questions, identified candidate vital signs, evaluated existing monitoring programs, developed scopes of work to fill data gaps, identified potential cooperators, and produced a written report.

Four workgroups submitted reports to the Network (shoreline change [See Appendix 1.10, *Shoreline Workgroup Report_Jan 2001*], estuarine nutrient enrichment [See Appendix 1.11, *Estuarine Nutrients Workgroup Report_Feb 2001*], freshwater quality [See Appendix 1.12, *Freshwater Workgroup Report_Jan 2001*], and data management [See Appendix 1.13, *Data Management Workgroup Report_Feb 2001*]).

Two of these–estuarine nutrients and shoreline change–wrote scopes of work to receive Network funding. The Steering Committee and Network staff identified qualified collaborators to address gaps in the issue areas, and subsequent reports have been completed for species and habitats of concern (Appendix 1.14, *Review of Vertebrate Monitoring_Fabre_Jan 2003*–Fabre 2003), recreation and visitor use impacts (Appendix 1.15, *Visitor Impact Phase I_Monz_Mar 2003* and Appendix 1.16, *Visitor Impact Vital Signs_Monz_Jul 2003*), and contaminants (Appendix 1.17 under development), in addition to a more thorough report on freshwater quality (Updated Appendix 1.18, *Wetlands Water Quality Preliminary Report_JamesPirri_May 2003*).

1.13 Vital Signs Monitoring Questions and Objectives

Five sets of monitoring objectives, one for each of the major vital signs monitoring projects in the Network, have emerged from the scoping process (See Table 1.7). The associated monitoring questions were used to identify vital signs (see Chapter 3) and guide protocol development (Chapter 5).

Table 1.7 Monitoring Objectives, Questions, and Vital Signs for the Northeast Coastal and Barrier Network

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Estuarine Eutrophication

Objective 1: Determine if nutrient loads to Park estuaries are increasing.

- **Question 1:** *Based on a four-week summertime index period, are there detectable inter-annual trends in the following estuarine water chemistry constituents: dissolved oxygen concentration, turbidity, attenuation of photosynthetically active radiation, temperature, and salinity?*
    - **Vital Sign 1:** Estuarine Water Chemistry
    - **Vital Sign 2:** Estuarine Water Clarity
- **Question 2:** *Based on a four-week summertime index period, are there detectable inter-annual trends in estuarine suspended chlorophyll concentrations?*
    - **Vital Sign 1:** Estuarine Water Quality
- **Question 3:** *Are there detectable inter-annual trends in the level of organic carbon in estuarine sediments?*
    - **Vital Sign 1:** Estuarine Sediment Organic Carbon
- **Question 4:** *Can the following land-use proxies for nutrient loads: human population density, non-point source discharge permits, permitted water withdrawals for domestic and agricultural consumption, fertilizer consumption, livestock populations be used to estimate nutrient inputs into Park estuaries?*
    - **Vital Sign 1:** Estuarine Nutrient Inputs

Objective 2: Determine if estuarine resources are changing in response to nutrient inputs.

- **Question 1:** *Is the distribution and abundance of submerged aquatic vegetation beds changing?*
  - **Vital Sign 1:** Seagrass Distribution
- **Question 2:** *Are there detectable inter-annual trends in the following within seagrass-bed measures of seagrass condition: shoot density, percent cover, and aerial biomass?*
  - **Vital Sign 1:** Seagrass Condition

Geomorphologic Change

Objective 1: Identification of the spatial and temporal variability in shoreline position.

- **Question 1:** *Is there a net displacement of the shoreline?*
- **Question 2:** *What are the seasonal dimensions of the displacement?*
- **Question 3:** *What are the storm related dimensions of the displacement?*
- **Question 4:** *Does the net displacement vary along shore?*
- **Question 5:** *Is there a spatial or temporal trend in the shoreline displacement?*
  - **Vital Sign 1 (Questions 1-5):** Shoreline Position

Objective 2: Identification of dimensional changes in the dune/beach topography.

- **Question 1:** *Is there a net change in topography***.**
- **Question 2:** *What are the seasonal dimensions of the topographic change?*
- **Question 3:** *What are the storm related dimensions of the topographic change?*
- **Question 4:** *Does topographic change vary along shore?*
- **Question 5:** *Is there a spatial or temporal trend in the topographic change?*
  - **Vital Sign (Questions 1-5):** Coastal Topography

Objective 3: To understand the factors contributing to geomorphological change.

- **Question 1:** *How are the fundamental hydrodynamic processes that affect shoreline responses changing over time?*
  - **Vital Sign 1: Marine Hydrography**
- **Question 2:** *How does offshore topography (e.g., sediment quality, bathymetry, and location of migrating shoals and bodies) affect changes in the beach/dune system?*
  - **Vital Sign 1:** Marine Geomorphology
- **Question 3:** *How does the location of man-made structures and disturbances affect shoreline change?*
  - **Vital Sign 1:** Anthropogenic Modifications

Salt Marsh Monitoring

Objective 1: To understand long term changes in salt marsh vegetation and nekton communities.

- **Question 1:** *Are salt marsh vegetation patterns (species composition and abundance changing over time (e.g., decades)?*
  - **Vital Sign 1:** Salt Marsh Vegetation Community Structure

- **Question 2:** *Is nekton community structure (species composition, abundance, and size structure) changing over time (e.g., decades)?*
  - **Vital Sign 1:** Salt Marsh Nekton Community Structure

Objective 2: To understand responses of salt marsh vegetation and nekton communities to environmental change.

- **Question 1:** *How do salt marsh communities change in response to perturbations (e.g. invasive species, oil spills, storms) in the environment?*
  - **Vital Sign 1:** Salt Marsh Vegetation Community Structure
  - **Vital Sign 2:** Salt Marsh Nekton Community Structure

Objective 3: To understand how salt marsh elevations respond to local sea-level rise.

- **Question 1:** *Are salt marsh surface elevation trajectories changing over time (e.g., decades), and if so, what factors are contributing to observed elevation changes (e.g., surface versus subsurface processes, changes in organic matter accumulation)?*
  - **Vital Sign 1:** Salt Marsh Sediment Elevation
- **Question 2:** *Are salt marsh surface elevation trajectories keeping pace with the local rate of sea-level rise?*
  - **Vital Sign 1:** Salt Marsh Sediment Elevation

Visitor Impacts

Objective 1: Understand the Character of Park Use as an Agent of Change in CBN Parks.

- **Question 1:** *What types of official park use activity currently exist?*
- **Question 2:** *What types of unofficial and illegal park use activity currently exist?*
- **Question 3:** *What is the amount of park use for each official type?*
- **Question 4:** *What is the amount of park use for those unofficial/illegal types that have been documented?*
- **Question 5:** *What is the spatial distribution of current visitor use?*
- **Question 6:** *What is the temporal distribution of current visitor use?*
- **Question 7:** *What are the trends of visitor use over the past decade or more?*
  - **Vital Sign 1 (Questions 1-7):** Park Usage

Objective 2: Understand the Types, Patterns and Trends of Habitat Degradation Associated With Unofficial Trails and Recreation Sites.

Question 1: *What types of habitat degradation exist?*

- **Question 2:** *What is the extent and distribution of social trails?*
- **Question 3:** *What is the extent and distribution of unofficial recreation sites?*
- **Question 4:** *What are the spatial and temporal trends of social trails and unofficial recreation sites?*
- **Question 5:** *What is the spatial relationship between social trails and unofficial recreation sites and known habitats of RTE species?*
- **Question 6:** *To what extent are the patterns of social trails and unofficial recreational use associated with the patterns of park use?*
- **Question 7:** *What are the other types of habitat degradation that are attributable to park use activities (e.g., illegal collection, tree damage)?*
  - **Vital Sign 1 (Questions 1-7):** Habitat Alteration

Objective 3: Understand the Patterns and Trends of Direct Ground Disturbance to Terrestrial and Benthic Habitats by Park Use.

- **Question 1:** *What is the extent of ground disturbance within terrestrial habitats?*
- **Question 2:** *What is the extent of ground disturbance within benthic habitats?*
- **Question 3:** *What is the distribution of ground disturbance within terrestrial habitats?*
- **Question 4:** *What is the distribution of ground disturbance within benthic habitats?*
- **Question 5:** *What are the spatial and temporal trends of direct ground disturbance?*
  - **Vital Sign 1 (Questions 1-5):** Habitat Alteration

Objective 4: Understand the Types, Patterns and Trends of Wildlife Disturbance Associated With Park Use.

- **Question 1:** *What types of use-related wildlife disturbance exist?*
- **Question 2:** *Specificially, what types of wildlife attraction behavior exist?*
- **Question 3:** *Where and when does each type of wildlife disturbance occur most often?*
- **Question 4:** *What is the spatial and temporal distribution of wildlife attraction behavior?*
- **Question 5:** *To what extent is the distribution of wildlife attraction behavior related to the distribution of park use?*

- **Question 6:** *What are the spatial and temporal trends of wildlife disturbance, including wildlife attraction behavior?*
  - **Vital Sign 1 (Questions 1-6):** Wildlife Disturbance

Landscape Change

Objective 1: Quantify landscape change in and around Northeast Coastal and Barrier Network Parks.

- **Question 1:** *How are the dominant habitat cover types changing over time (both terrestrial and subtidal aquatic habitats)?*
  - **Vital Sign 1:** Landscape Pattern
- **Question 2:** *How are landscape pattern metrics (e.g., indices of habitat: patch size, patch density, fragmentation, and isolation) changing over time?*
  - **Vital Sign 1:** Landscape Pattern

1.14 Pre-existing Monitoring Programs and Partnership Opportunities

As part of the Network's scoping effort, its staff and cooperators reviewed existing monitoring programs occurring within or near Network parks. These reviews provide multiple benefits to the Network Inventory and Monitoring Program—a broad survey of valuable natural resource information for Network parks, access to data sets and protocols that can be incorporated into the vital signs monitoring program, and information on potential collaborators for inventory and monitoring projects.

For example, the estuarine nutrients vital signs project has developed submerged aquatic vegetation protocols following the SeagrassNet model. Also, the coastal geomorphology vital signs project is developing protocols both based on historic topographic surveys, GPS surveys, and emerging LIDAR technology, the latter in partnership with USGS and NASA. These projects are detailed in subsequent chapters. The results of the reviews are compiled into one summary table (See Appendix 1.19, *Existing Monitoring Programs_Sep2003*), and project-specific review documents can be found as the following appendices:

- Appendix 1.2–*CACO Conceptual Framework_Roman_Apr 1999*
- Appendix 1.20–*NCBN Phase I Report_Oct 2002*
- Appendix 1.18–*Wetlands Water Quality Preliminary Report_JamesPirri_May 2003*
- Appendix ?–*Estuarine Nutrients Report_Neckles_Sep 2002*
- Appendix 1.9–*Vital Signs Workshop Report_Apr 2000*
- Appendix 1.22–*CACO Salt Marsh Nekton Protocol_Raposa_Dec 2001*
- Appendix 1.23–*CACO Salt Marsh Vegetation Protocol_Roman_Dec 2001*
- Appendix 1.24–*Geomorphology Workshop Report_Duffy_ Oct 2002*
- Appendix 1.25–*Inventory Study Plan_Stevens_2002*
- Appendix 1.14–*Review of Vertebrate Monitoring_Fabre_Jan 2003*
- Appendix 1.15–*Visitor Impact Phase I_Monz_Mar 2003*

- Appendix 1.26–*NCBN Weather Station Assessment May 11 2004*

There is wide variation in the monitoring programs associated with Network parks and resources. These range from short term local projects with only informal protocols, to long term regional or national programs with tested and published protocols. Some of these projects will become part of the overall vital signs monitoring program. Numerous and widespread monitoring programs (historic or ongoing) have been conducted for land cover and vegetation types, freshwater and estuarine water quality, submerged aquatic vegetation, mussels and oysters, fisheries, land birds, shorebirds, and waterfowl, and to a lesser degree mammals, reptiles, and amphibians. Also, species-specific monitoring programs have occurred for piping plover, tern species, rare coastal plant species, white-tailed and sika deer, and Assateague horses. The ongoing programs that can be incorporated into Network vital signs monitoring are listed in Appendix 1.27, *Ongoing vital signs programs*, which identifies each program, the park(s) in which it occurs, and the vital sign(s) to which it relates.

1.15 Implementation of a Water Quality Monitoring Component for the Network

The NCBN has decided to incorporate water quality monitoring into the overall vital signs monitoring program rather than to create a distinct water quality program. Therefore various water quality issues have become part of the vital signs scoping and program development process. As noted earlier, a water quality breakout group was established at the Vital Signs Scoping Workshop; its report is part of Appendix 1.9, *Vital Signs Workshop Report_Apr 2000*. Subsequently, issue-based workgroups were formed and reports produced for freshwater (Appendix 1.12, *Freshwater Workgroup Report_Jan 2001*) and estuarine nutrients (Appendix 1.11, *Estuarine Nutrients Workgroup Report_Feb 2001*).

To provide more comprehensive information on Network park wetlands and water quality, the NCBN completed a report to identify any park waters designated as Outstanding Resource Waters. This report also identified any park waters covered by the Clean Water Act's section 305(b) Water Quality Reports or section 303(d) Impaired Water bodies Lists. Also, reports on contaminants in Park waters and sediments have been completed for each Network park (Appendices 1.28, *Water/Sediment contaminants*). "Estuarine nutrients" is one of the five major project areas chosen for vital signs monitoring. These include both estuarine water quality and estuarine nutrient inputs. This monitoring project is detailed in subsequent chapters.

Chapter 2
Conceptual Models

2.1 Conceptual Models and the Development of an Ecological Monitoring Program

Ecological monitoring programs often fail to formulate meaningful monitoring strategies. Conceptual models provide a framework for clarifying these strategies, enabling us to progress from general monitoring questions to more specific ones (Gross, 2003).

Conceptual models are tools to help us understand ecological complexity. We use them to:

- simplify and clarify the relationships among ecosystem components and processes
- organize large amounts of information
- see how an ecosystem's components affect one another and influence other ecosystems
- communicate our understanding of an ecosystem to other developers

Conceptual models are especially effective in Network-wide, multi-park programs where the complex interactions among ecosystems within a group of parks are difficult to interpret. A conceptual model identifies or maps the physical and biological components and their links in an ecosystem. Most useful models do not try to name or describe every component of an ecosystem. Instead, they depict major components and interactions. For examples:

- major external activities or processes that influence the ecosystem
- problems or products of human activities or natural events that alter the quality or integrity of the ecosystem
- measurable changes in ecosystem structure, function, or processes

We use conceptual models to structure, select, and develop monitoring protocols. But we don't require them to be comprehensive accounts of an entire ecosystem. They neither explain nor list all the mechanisms and outcomes of ecosystem evolution. Thus, a conceptual model may understate the comprehensive nature of an ecosystem, but it will show or suggest its complexity and its interactions with other ecosystems, many of which are unknown (Roman and Barrett 1999; see Appendix 1).

2.2 **Types of Conceptual Models**

Monitoring programs frequently use one of two model types, *control models* or *stressor models,* or a combination of both. Control models simulate feedbacks and elementary connections between system components. They show the links between *agents of change, stressors* and *ecosystem responses.* Stressor models usually do not map feedback loops and include a subset of system components (Gross, 2003). Stressor models show the major external activities or processes that affect an ecosystem and how it responds to these changes and associated problems. Since we can define the links within conceptual models in various ways, no one conceptual model is necessarily more correct or useful than another.

Conceptual models consist of any combination of narratives, tables, matrices of factors, and box-and-arrow diagrams. Most monitoring programs use a combination of these forms. The NCBN used a conceptual model framework when it developed its long-term monitoring protocols for Cape Cod National Seashore (Roman and Barrett 1999). Since Cape Cod NS faces many of the park management issues other Atlantic coastal parks in the NCBN do, the National Park Service is using it as a prototype monitoring park for the Atlantic and Gulf Coast biogeographic region. Also, the conceptual model for CAPE COD NS serves as a guide in the ongoing refinement of the NCBN's vital signs program.

2.3 **Northeast Coastal and Barrier Network's Ecosystem Models**

The NCBN's monitoring program recognizes and responds to the environmental processes and human induced threats to ecosystems that operate at various temporal and spatial scales (Roman & Barrett, 1999). Like the Cape Cod NS LTEM program, the NCBN vital signs program has developed a number of stressor models to represent the five main ecosystem types within its parks. These models show the complex relationships among:

- *Agents of Change*, or the major external activities or processes that influence the natural system, which can be natural processes or human activities
- *Stressors* to each system, or the associated problems or products of human activities or natural events that alter the quality or integrity of the ecosystem
- *Ecosystem Responses*, or the measurable changes in ecosystem structure, function, or process

Initially, the NCBN developed a single hierarchical model depicting the overall *agents of change*, *stressors,* and *ecosystem responses* relative to all eight of the NCBN parks. Using this model as a basis, the NCBN developed five hierarchical ecosystem models and one project-based visitor impacts model. This visitor impact model is issue-based and can be applied to any of the five ecosystem types presented in the other models. These seven models demonstrate some of the human and natural activities and processes that often are the sources of stress on coastal ecosystems. These models continue to serve as a foundation for selecting protocols and protocol attributes for the NCBN's monitoring program.

The NCBN General Ecosystem model is applicable to all NCBN parks and is a template for the development of the ecosystem specific models. The five ecosystem models are ecosystem specific to estuaries, salt marshes, freshwater, beaches/dunes, and uplands. The Network developed its general model from information gathered during scoping workshops (both NPS and USGS), NCBN working group meetings, technical steering committee meetings and cooperator/I&M staff meetings. These models provide guidance and structure for the development of monitoring protocols.

2.4 **The NCBN General Ecosystem Model**

The Network's general model (see Figure 2.1) focuses on five broad categories of *agents of change*:

- Natural Disturbance, which includes geomorphic and biotic processes. For example, sea level rise, predation, grazing, fires, and storms (hurricanes, floods, droughts)
- Land Use, which includes any change in activity in land use patterns that influence natural systems. For example, watershed development, atmospheric inputs (pollution), population trends, and agriculture
- Resource Consumption, such as groundwater extraction, fin and shell fishing, hunting, and sand mining
- Visitor and Recreation Use, which includes activities such as trail formation, vegetation trampling, soil compaction, and wildlife disturbance
- Disasters, such as oil and other chemical spills, which can also play a role in shaping natural systems

In addition, watershed condition significantly affects coastal environmental quality in Parks. Coastal watersheds or land areas that drain into the coastal zone are nature's dynamic hydrologic systems, creating and sustaining aquatic ecosystems. Unfortunately, impaired watersheds also convey pollutants and sediments into park waters, undermining critical habitat of the coastal Parks. Many water quality issues and ecosystem problems derive from watershed conditions beyond any specific water source. To respond effectively, NPS needs to better understand watershed use, conditions, trends, and problems affecting all coastal watersheds where Parks are located. Thus, NPS is developing a coordinated strategy for assessing coastal park watersheds and addressing these threats.

In the general model, six *stressors* result from these five categories of *agents of change*: altered hydrologic properties, altered landscape, invasive species, over harvesting, altered sediment inputs, and altered chemical inputs. The general model groups *ecosystem responses* into three major categories:

- Biotic Structure Changes that can modify community composition, species interactions, biodiversity, and abundance
- Ecosystem Function Changes or alterations in productivity, nutrient cycling, and energy flow
- Physical Environment Changes that can encompass changes in soil, water, and air chemistry

Depending on the ecosystem type (e.g. estuaries, salt marshes, etc.), the *agents of change* can form a wide array of links to the *stressors* listed in the model. For example, a change in land use patterns, with a corresponding increase in watershed development and urbanization within the coastal zone, can modify chemical, sediment, and hydrologic inputs within all coastal ecosystems. Woodlands become commercial or housing developments. The ecosystem responds to this urbanization; wildlife habitat is destroyed; there is increased nutrient loading from septic and sewer systems; changes in air chemistry result from automobile emissions; and community composition changes, often dramatically.

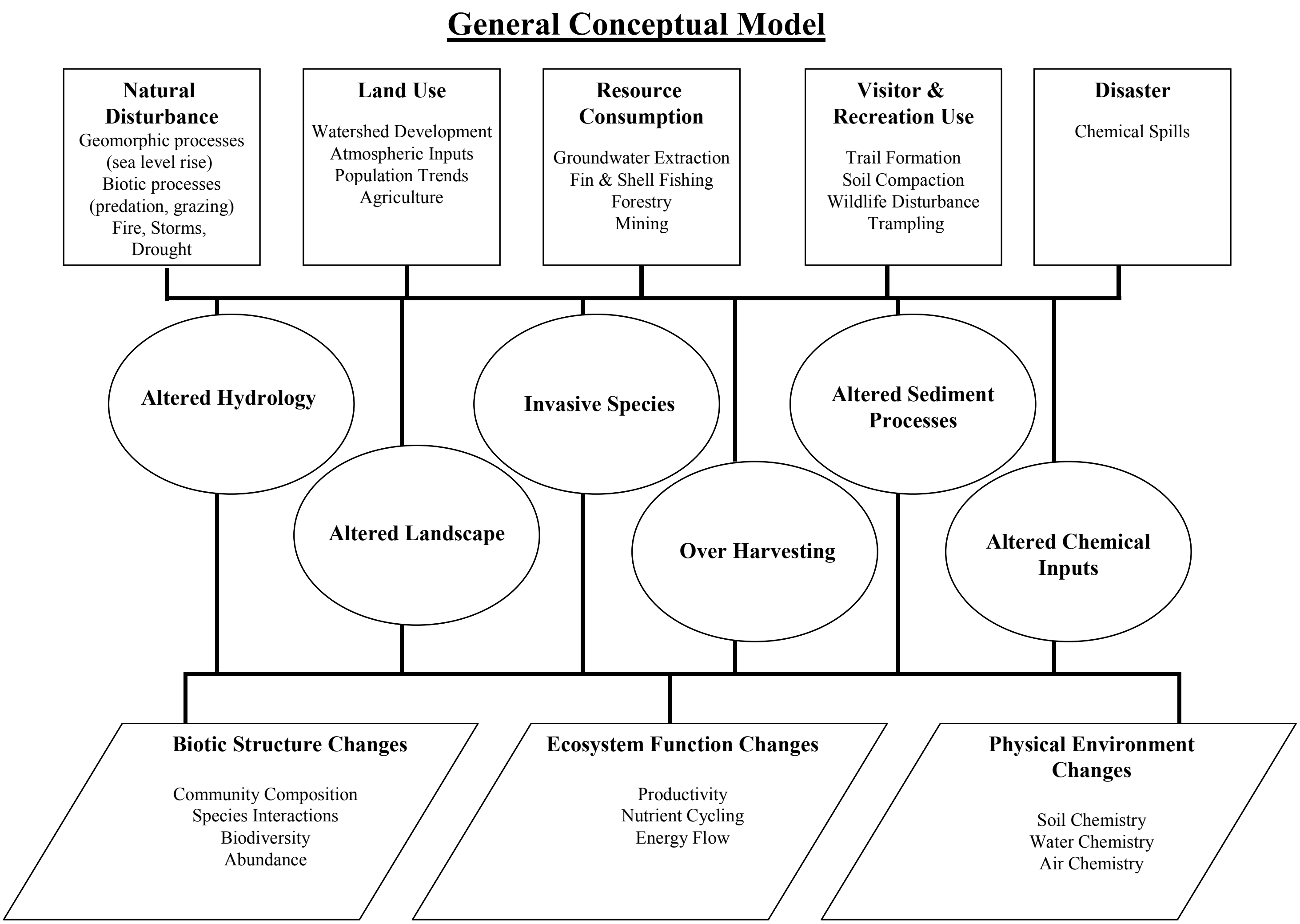

Figure 2.1. The Northeast Coastal and Barrier Network General Conceptual Ecosystem Model.

2.5 **Five NCBN Ecosystem Models**

2.5.1 **Salt Marsh Ecosystem Model**

Salt marsh ecosystems provide habitat for many species of recreational and commercial fishes, forage species, migratory shorebirds, and water birds. They act as erosion buffers and filters of nutrient inputs by intercepting and absorbing land derived runoff (see Figure 2.2). A large percentage of the United States's salt marshes have been altered, degraded, and lost over the past century. Restoration and subsequent monitoring of salt marsh habitat has become only recently a management tool to rectify past environmental change (see Roman *et al*. 2001 for more details).

An estimated fifty percent of the USA's coastal wetlands have been completely lost, mostly by filling and dredging activities (Dahl 1990, Tiner 1984). Salt marshes have a long history of alteration by extensive Networks of ditches, which have been used for mosquito control and salt hay farming. Tidal exchange has been restricted by roads, causeways, bridges, and dikes, (Daiber 1986, Roman *et al.* 2000). As the coastal corridor has become more urbanized, watersheds have become increasingly developed. Salt marsh acreage has declined and become fragmented. Urbanization has brought more septic and sewer systems, more air pollution, and intensified recreational use of coastal areas.

The ecosystem structure of salt marshes dramatically changes in response to ditching activities (*e.g.*, Bourn and Cottam 1950, Niering and Warren 1980) and the restriction of tidal flow (*e.g.*, Roman *et al.* 1984, 1995). Ditching can cause a marsh to become drier. Less salt- or flood-tolerant species may dominate (*e.g.*, *Iva frutescens* and high marsh species). Restricting tidal flow often results in a change from *Spartina*-dominated to *Phragmites australis*-dominated marshes, which allows for the expansion of other invasive species, leading to further changes in ecosystem structure and function. Fortunately, re-establishment of hydrologic conditions that were altered by ditching or tidal restriction often initiates a change or recovery back to typical marsh vegetation (Burdick *et al.* 1997).

Increased loading of nutrients or toxics to salt marshes, from coastal development served by on-site septic systems, alters ecosystem function and water quality. With nutrient enrichment of the coastal zone, we expect primary production to increase, leading to habitat disturbances. Sampling along a nutrient gradient in Narragansett Bay, Nixon and Oviatt (1973) found that production was substantially greater in high nutrient areas of the Bay compared to the lesser-developed and low nutrient sites.

Global climate change phenomena, such as a rise in sea level, can influence salt marsh ecosystems. Current estimates suggest that sea level along the Atlantic coast will rise 0.5m by 2100 (Intergovernmental Panel on Climate Change, 1995). Changes in vegetation, sedimentation, and erosion rates, or the conversion of marsh to mudflats or open water could result (Titus 1991). Salt marshes in New England appear to be adjusting to the rise in sea level, but some locations report changes indicating that the marshes are getting wetter and tending toward submergence or drowning (Warren and Niering 1993, Roman *et al.* 1997). Inlet migration significantly influences the hydrologic characteristics and sedimentation of marsh-dominated estuaries (Aubrey and Speer 1985). Dramatic changes in structure can be an ecosystem's response to these new and often unpredictable inlet dynamics and sea level rise (Roman *et al.* 1997).

Other factors related to climate change can affect salt marsh ecosystems. For example, higher air temperatures boost evaporation rates, leading to an increase in marsh salinities and changes in soil chemistry. This could result in the expansion of extreme salt tolerant halophytes and un-vegetated marsh pannes. Currently, salt marshes in more southern latitudes (*e.g.*, southeast Atlantic) with warmer climates generally have greater occurrences of halophytes adapted to extremely high soil salinity conditions (Bertness 1999).

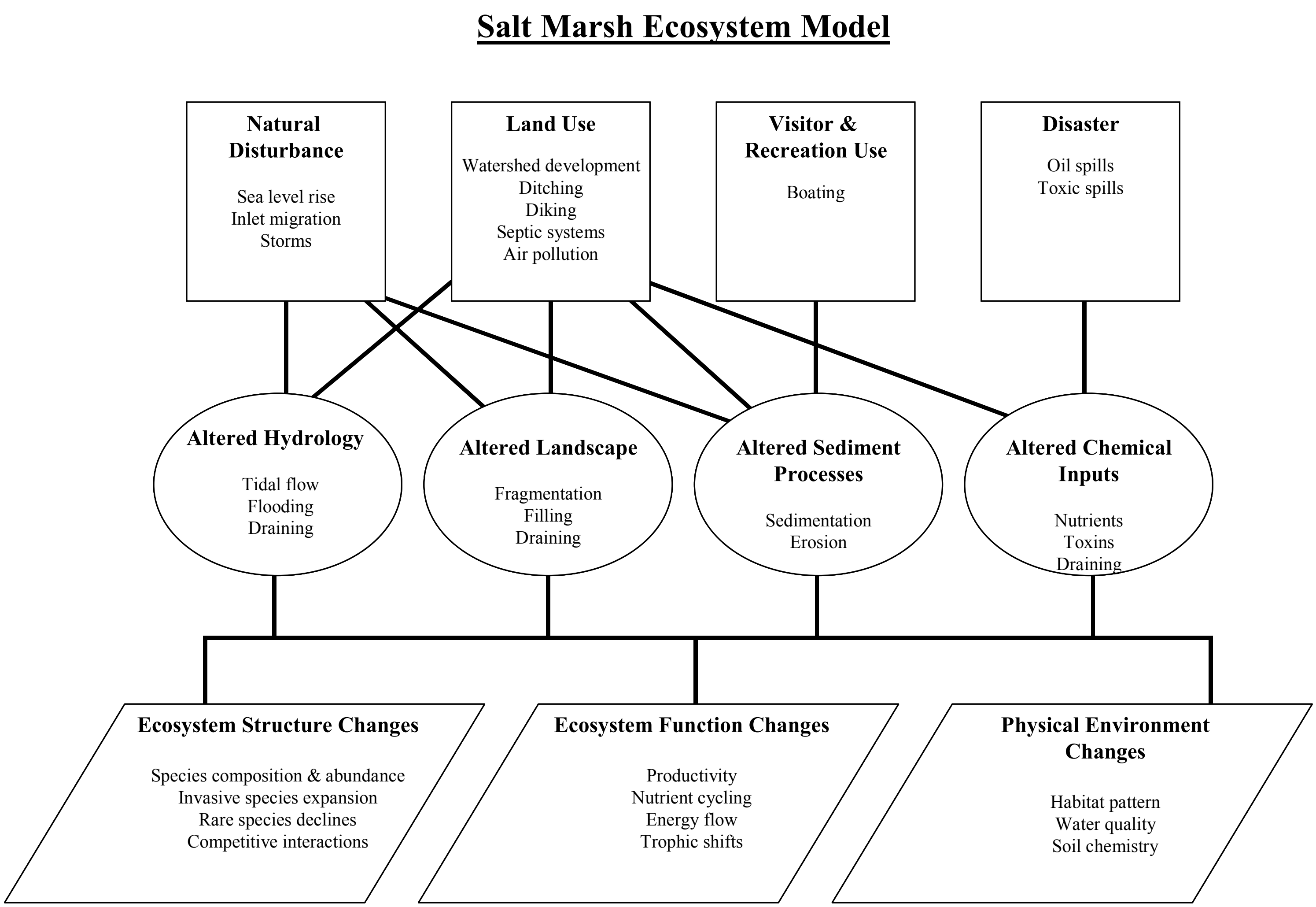

Figure 2.2 Northeast Coastal and Barrier Network Salt Marsh Ecosystem Model

2.5.2 **Estuarine Ecosystem Model**

Estuarine ecosystems are deep and shallow subtidal habitats and adjacent intertidal wetlands, usually semi-enclosed by land, and having open, partially obstructed, or sporadic access to the ocean. The ocean water is at least occasionally diluted by freshwater runoff (Mitsch and Gosselink, 1986). Many different habitat types are found in and around estuaries, including shallow open waters, freshwater and salt marshes, sandy beaches, mud and sand flats, rocky shores, oyster reefs, mangrove forests, river deltas, tidal pools, sea grass and kelp beds, and wooded swamps.

Estuaries are critical for the survival of many species. Many marine organisms, including most commercially valuable fish species, depend on estuaries during some stages of their development. Tens of thousands of birds, mammals, fish, and other wildlife depend on estuarine habitats as places to live, feed, and reproduce. Estuaries provide ideal respites for migratory birds to rest and refuel during their journeys. And many species of fish and shellfish rely on the sheltered waters of estuaries as protected places to spawn, giving them the nickname "nurseries of the sea." (NERRS, 2003).

The wetlands that fringe many estuaries are critical habitat for wildlife, and perform many valuable services. As the water flows through fresh and salt marshes, much of the sediment and pollutants from the uplands are filtered out, benefiting both human and marine life. Wetland plants and soils act as a natural buffer between the land and ocean, absorbing flood waters and dissipating storm surges. This helps protect upland organisms and valuable real estate from storm and flood damage. Salt marsh grasses and other estuarine plants also help prevent erosion and stabilize the shoreline (NERRS, 2003).

Our rapidly increasing human population demands more and more of our natural resources. Protecting these resources for their natural and aesthetic values has become both critical and more challenging. Channels have been dredged within estuaries; marshes and tidal flats have been filled; waters have become polluted; and shorelines have been reconstructed to accommodate our need for housing, transportation, and food. National Park Service units along the North Atlantic coast protect approximately 1,891 square kilometers between Virginia and Maine. One fourth of this land area is submerged, including many coastal bays, estuaries, and lagoons (NPS 2000).

2.5.2.1 **Agents of Change**

The conceptual model for estuarine ecosystems in the NCBN identifies four agents of change: Natural Disturbance, Land Use, Resource Consumption, and Visitor and Recreation Use. These include resource consumption, visitor recreation, storms, disease, and geomorphic and biotic processes (see Figure 2.3).

<u>Natural Disturbance</u>
Natural disturbances can completely alter an ecosystem. Shoreline geomorphic processes (e.g. beach and barrier migration; alongshore sediment transport) can alter depth profiles,

change inlet morphometries, and bury estuarine biota. Natural coastal erosion is exacerbated by storms and hurricanes. For example, severe weather can create or block inlets to an estuary, altering hydrologic properties and the landscape. The biotic processes, within an estuarine ecosystem will likely change and affect other processes. Grazing (e.g. by Canada geese) and disturbance of bottom sediments (e.g. by foraging activities of horseshoe crabs and cownose rays) can have local impacts on sea grass cover. Disease may have widespread impacts on estuarine sea grasses. For example, in the 1930's, eelgrass (*Zostera marina* L.) populations declined throughout most of its range from an epidemic of wasting disease (infection by the marine slime mould *Labyrinthula zosterae*).

Land Use/Disasters

The Northeast (from Maine to Maryland) accounts for about one third of the coastal population of the United States (NOAA 1998). The population density of this narrow coastal fringe is more than double that of any other region of the country, and it continues to grow. Therefore, estuaries in the northeastern USA are particularly threatened by human disturbances within the densely populated coastal zone (Roman et al. 2000). Direct disturbance arises from coastal construction, dredge and fill activities, and shoreline stabilization (e.g. with bulkheads, revetments, riprap, and other types of shoreline armor). Indirect effects of residential, agricultural, and urban watershed development include increased nutrient loads to estuarine environments from atmospheric inputs, point source discharges, and diffuse non-point sources.

Resource Consumption

The loss or lack of some resources can dramatically affect estuarine ecosystems. For example, much of the watershed area of the NPS coastal ecosystems lies outside protective park boundaries and is subject to intense developmental pressures. More and more groundwater is required for residential and commercial use including agriculture. Excessive groundwater extraction can decrease freshwater input to estuarine ecosystems, thereby altering the flushing rates, retention times, and salinity regimes. We know of many acute and chronic effects of certain commercial fishing practices. For example, trawling, dredging, and raking for bay scallops and hard clams can damage eelgrass beds on the mid-Atlantic coast. Dragging for blue mussels can have severe and long lasting effects on eelgrass in New England. Fin and shellfish aquaculture operations can shade estuarine substrate and introduce large amounts of organic matter and nitrogenous waste into estuarine waters.

Visitor and Recreation Use

As populations in the Northeast continue to grow, we can expect more visitors to our Northeast National Parks, which will alter landscapes, sediment processes, and the chemical composition of the ecosystem For example, visitors to the NCBN parks commonly use boats and jet-skis as recreational vehicles, which alter sediment processes by increasing turbidity in shallower aquatic areas such as estuaries. Fuel spills and the discharge of contaminated bilge water into estuarine waters from pleasure boats change chemical composition. Direct damage to sea grass beds from boat propellers, anchors, and mooring chains increases local disturbance with the potential for large-scale cumulative impacts.

2.5.2.2 Stressors

Altered Hydrologic Processes

Water plays a vital role in maintaining a healthy estuarine ecosystem. Changes to tidal flow and variation in freshwater input can affect salinity, water temperature, and depth of water within an estuary. Natural events (e.g. storms) cause short-term increases in wave size and frequency and current speed and volume. Natural events (e.g. barrier breaches, inlet closure) and human disturbance (e.g. shoreline stabilization) lead to long-term alterations in wave climate and current regime.

Altered Landscape

Most *agents of change* can cause small-scale disturbances in estuarine environments that, on a larger scale, result in fragmentation of specific habitat types. For example, direct physical disturbance, biotic processes, and recreational boating activities can transform continuous sea grass beds into islands of vegetation surrounded by bare substrate. Filling or scouring caused by various natural and anthropogenic disturbances can alter estuarine depth contours.

Altered Sediment Processes

Some recreational activities, such as boating, can increase the turbidity within an estuary. The dredging of channels significantly increases turbidity within an ecosystem. Increased turbidity, in turn, decreases the availability of light, reducing water quality.

Increased land development for timber, agriculture, residential and commercial purposes can lead to erosion and excessive sedimentation. Sediments are often deposited downstream along coastal shorelines. Excessive sediments not only increase turbidity, but they can also carry excessive nutrients and pesticides, causing water quality problems. Natural disturbance events (e.g. storms and hurricanes) often cause erosion.

Altered Chemical Inputs

The major land-derived sources of nutrient pollution are fertilizers and wastewater (Valiela et al. 1992, Nixon 1995). Nutrients from agricultural fields and domestic septic systems enter streams and groundwater through runoff and leaching, where they contribute to non-point sources of enrichment. Domestic wastewater is also delivered to estuaries as point-source sewage discharge.

High rates of urbanization and agricultural expansion can lead to increased nutrient loads in streams and groundwater (Valiela et al. 1992, Nixon 1995). Atmospheric deposition of nitrogen from fossil fuel combustion and fertilizer volatilization may also form a significant portion of the total nitrogen load to coastal waters (Nixon 1995), particularly in estuaries that are large relative to the size of their watersheds (NRC 2000). Acute disasters such as oil and chemical spills may introduce toxins into estuarine environments.

2.5.2.3 **Ecosystem Responses**

Ecosystem Function Changes

Estuarine environments are among the most productive on earth, creating more organic matter each year than comparably-sized areas of forest, grassland, or agricultural land. A healthy, untended estuary produces from four to ten times the weight of organic matter produced by a cultivated corn field of the same size (NERRS, 2003).

Understanding how all the individual components of an ecosystem function together is impossible. However, we know that a healthy ecosystem depends on balancing its resources. When one or more of these resources are stressed beyond recovery, the ecosystem falters, or worse, begins to fail. Stressors such as altered hydrology, landscape, sediment processes and chemical inputs can all contribute to changes in native plant and animal productivity, trophic dynamics, energy flow, and nutrient cycling. Changes to ecosystem function ultimately alter biotic structure and the physical environment.

Biotic Structure Changes

The tidal, sheltered waters of estuaries support unique communities of plants and animals, specially adapted for life at the margin of the sea. The productivity and variety of estuarine habitats foster an abundance and diversity of wildlife. Shore birds, fish, crabs and lobsters, marine mammals, clams and other shellfish, marine worms, sea birds, and reptiles are some of the animals that live in estuaries. These animals are linked to one another and to specialized plants and microscopic organisms through complex food webs and other interactions. In an altered ecosystem, native species biodiversity and abundance often decline while exotic and invasive species abundance increases and expands. Changes in biotic structure include shifts in abundance of various native species, for example, competitive displacement of sea grasses by algae following nutrient enrichment. Cascading effects of shifts in composition and abundance of primary producers may include changes in the species composition and abundance of invertebrates and declines in fish and wildlife habitat value.

Physical Environment Changes

Changes in the physical characteristics of estuarine environments will surely have far-reaching effects on the health of the ecosystem. Any change in water quality, whether from increased concentrations of nutrients and suspended material, decreased oxygen availability in bottom waters, decreased transmission of light to submerged rooted vegetation, increased organic content of sediments, or altered biogeochemical cycling, can be critical. Altered landscapes and sediment processes can change bottom topography, depth contours, and other hydrologic properties. These changes in the physical environment will influence and be influenced by the structure of estuarine biotic communities, and ultimately, determine ecosystem function.

Estuarine Ecosystem Model

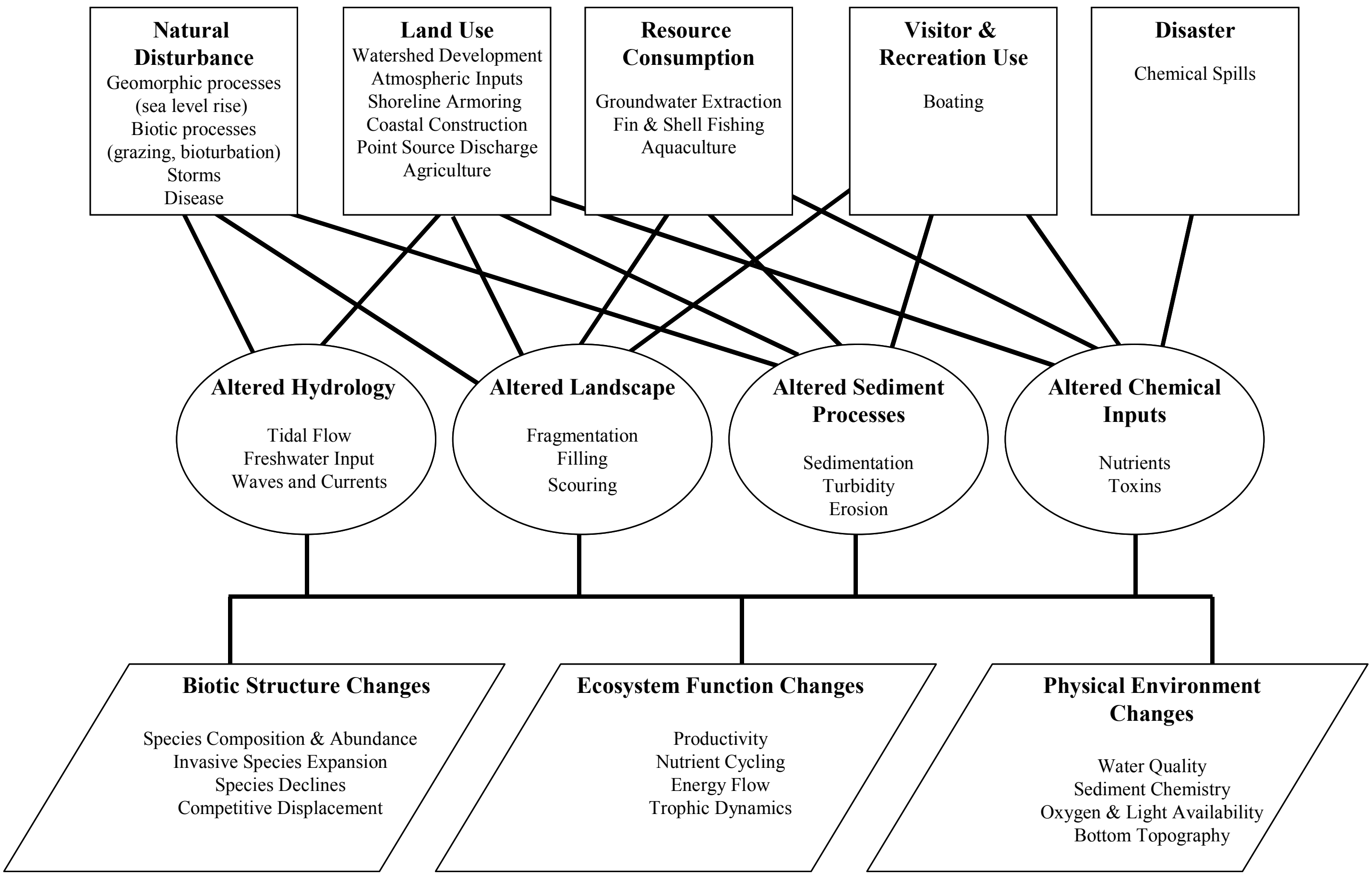

Figure 2.3 The Northeast Coastal and Barrier Network Estuarine Ecosystem Model

2.5.3 **Beach/Dune Ecosystem Model**

Several fundamental processes drive the formation and evolution of Beach/ Dune habitat, but a controlling factor in their expression is their shallow geologic framework. Defined here as the geologic properties of the near subsurface, the regional geologic framework exercises considerable influence over the response of near shore and onshore environments to natural forces. Although not a process, this geologic framework is critical to our understanding of short and long-term changes in coastal habitats. Operating on top of this framework are numerous natural and anthropogenic factors.

The primary natural processes influencing Beach/Dune habitat are hydrographic conditions, sediment supply, and a suite of natural disturbance factors operating at local, regional, and global scales. Hydrographic conditions encompass a combination of physical and hydrologic features, such as the near shore system of bars, ridges, and shoals, and the continuous movement of water in the form of currents, waves, and tides. Collectively, these features and forces direct and control the movement of sediment through the near shore system.

Ultimately, the presence of Beach/Dune habitat depends upon the availability of appropriately sized sediments within near shore coastal environments. Finite in supply, especially along the mid-Atlantic coast, sediment availability serves as a limiting factor in the landform’s response to the forces of wind and waves. Sediment supply is susceptible to human disturbance and interruptions. When subject to prolonged changes in sediment supply, landforms may disrupt the physical environment and associated biota.

In the mid-Atlantic region of North America, natural disturbances consist mainly of atmospheric processes that provide both continuous and episodic energetic inputs to the system. They create wind, waves, and currents, the primary motive forces driving sediment transport in Beach /Dune habitat. While atmospheric processes are persistent, relative sea level change and storm events are the dominant factors.

Changes in relative sea level result from a variety of global and local inputs including changes in ocean volume, tectonic seafloor shifts, and localized subsidence and rebound at the continental margins. Regardless of cause, sea level change leads to the gradual shifting of the land/water interface (shoreline) in long-term patterns of retreat or advance. In contrast, storms provide short-term energy pulses that can rapidly reshape Beach/Dune habitat. Whether expressed as tropical (e.g. hurricanes) or extra-tropical (e.g. nor’easters) systems, storm events move very large volumes of sediment (erosion and deposition) and can cause major habitat alterations through overwash-induced flooding and inlet formation. They may also cause substantial changes to near shore subaqueous topography and subsequently affect hydrographic processes.

Anthropogenic activities also have the potential to substantively alter the natural processes controlling Beach/Dune habitat, primarily though changes in land use within the coastal zone. Most significant are shoreline stabilization activities (e.g. groins; jetties;

bulkheads), beach “nourishment” (to artificially increase local sediment supply), and dredging activities. Each of these practices has the potential to alter existing hydrographic conditions and sediment supply, and influence natural patterns of erosion/deposition, overwash, inlet formation, and migration. When this occurs, core processes are altered, and naturally occurring stressors may begin to operate outside the range of natural variation. For example, a chronic sediment deficit caused by an upstream groin field or jetty system can result in dramatic changes in the volume and elevation of downdrift landforms. In turn, lower elevations facilitate overwash during storms and, consequently, may increase the potential for breaching and new inlet formation. Both are naturally occurring stressors acting on coastal barriers, which are subject to influence by human activities.

Each of the stressors identified in the conceptual model (see Figure 2.4) cause change in Beach/Dune habitat, regardless of whether they operate as natural phenomena or as a product of human activities. The magnitude and scope of the resultant ecosystem response is complex, highly variable, and often cumulative. For example, human-induced reduction in sediment supply can exacerbate local rates of natural shoreline erosion, creating a situation where part of the observed ecosystem response is natural and part is anthropogenic.

In general, the most immediate ecosystem response to stressors is a direct change in the physical environment. At the extreme, this includes the loss and/or gain of habitats, such as when coastal erosion creates new aquatic habitat at the expense of terrestrial or landscape-level reformation, which may occur during strong storms. More subtle physical responses also include changes in geochemical and hydrologic conditions, such as alterations in groundwater quality and quantity.

Ecosystem response in the Beach/Dune Habitat can also be cascading. Stressor-induced changes in the physical environment often elicit secondary responses, such as changes in ecosystem structure or function. Structural responses, such as change in species composition or competitive interactions, generally reflect landscape-level alterations in the quantity and quality of specific habitat attributes. Similarly, functional responses such as changes in productivity or nutrient cycling may occur, often as a product of storm events and the associated reduction in habitat complexity.

Beach/Spits/Dune Ecosystem Model

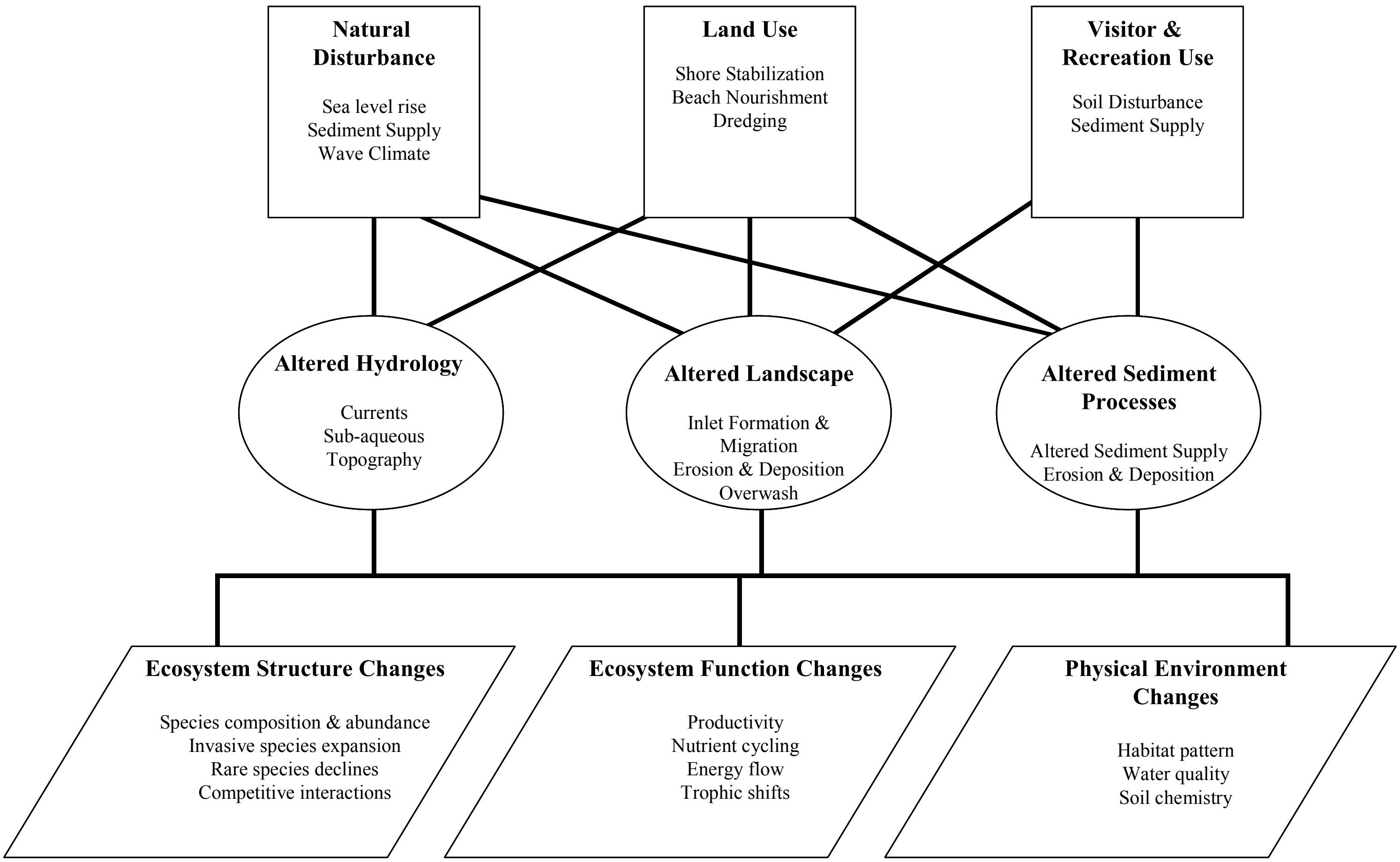

Figure 2.4 Northeast Coastal and Barrier Network Beach/Dune Ecosystem Model

2.5.4 Coastal Upland Ecosystem Model

Coastal uplands are transitional areas that experience strong gradients in environmental conditions across the shoreline to inland interface. The physical features and biotic communities are structured largely according to these gradients. For example, the coastal edge of uplands requires the biota to tolerate wide ranging meteorological conditions and geomorphologic processes (salt spray, wind, sand deposition, large storm events). But in the more buffered and resource-rich inland areas, competition for resources is a more significant factor in the structuring of biotic communities. This results in an overall pattern of relatively narrow bands of strictly coastal upland communities, including those on dunes, which are in front of larger areas of forest, scrubland, or grassland whose structure and function is more like that of similar inland areas.

Coastal uplands are important for the retention of runoff waters, which decreases estuarine flooding and erosion and filters and removes pollutants before they reach coastal waters. Coastal uplands also are important for the stability of the water table, which affects the diffusion zone between fresh water and salt water environments. These areas also provide habitat for a variety of plant and animal species, and they can be particularly important for animals that utilize the shelter provided by upland areas as well as estuarine or marine food resources. See figure 2.5.

2.5.4.1 **Agents of Change**

The NCBN conceptual model for coastal uplands ecosystems recognizes four agents of change: Natural Disturbance, Land Use, Resource Consumption, and Visitor and Recreation Use.

<u>Natural Disturbances</u>
Although uplands are probably the most buffered component of coastal systems, many natural processes still create disturbances that operate on both small and large spatial and temporal scales. Coastal areas are particularly susceptible to disturbance from extreme storm events, and the most powerful storms along the Atlantic coast of North America (hurricanes and winter “nor’easters”) are fueled by open water, causing their strongest impacts along the immediate coast. Flood impacts occur from both ocean storm surge and inland fresh water runoff. These can create short or long term changes to hydrologic and superficial features. Flooding also changes soil and biotic conditions and processes through the transport of sediments and soils and the removal of vegetation. High winds from strong storms can create isolated or large scale blowdowns of exposed trees.

Fire, whether generated by lightning or used by Native Americans as a landscape management tool, has always affected the structure and processes of Atlantic coastal upland ecosystems. Although historic fire cycles likely differ among NCBN park ecosystems, the last century of fire suppression throughout the region has certainly changed the dynamics of all park ecosystems. In particular, areas that had adapted to frequent, low-intensity wildfires now have fewer early and mid-successional species and expanding shade-tolerant tree populations. The relative importance of fire is heightened when fire is suppressed, as longer living and more densely packed trees are more susceptible to insect and pathogen disturbance (Covington et al. 1994). Eventually, trees killed by drought, insects, or pathogens become fuels; thus, there is a likelihood of more intense, larger fires.

The introduction or removal of species by humans, whether purposeful or incidental, is another important agent of disturbance in these systems. Invasive plant species are now ubiquitous in upland areas, often taking advantage of gaps in vegetative cover created by disturbances to quickly establish populations, which expand to create additional direct and indirect impacts on native plant and animal populations. Also, the removal of top predators from the highly populated coastal areas of the Northeast has direct and indirect effects on both animal and plant populations. Probably, the most significant impact of predator removal has been the removal of white-tailed deer predators, resulting in an increase in deer populations.

Infection from pathogens, and grazing or browsing by animals, can alter the vegetation of coastal upland ecosystems. For example, the abundance of white-tailed deer and their impact on the landscape is a significant issue for many of the NCBN parks. Deer overpopulation can influence the presence, absence, and abundance of plants and other wildlife. In many forests, over-browsing of native shrub and tree seedlings leaves little or no ground cover except for species avoided by deer. One of these–the invasive Japanese barberry–can create virtual monocultures in deer-browsed areas.

Land Use

Northeastern coastal uplands are among the most heavily populated and developed areas in North America. Development within coastal upland watersheds and agricultural land uses alter the hydrologic properties, sediment processes, and chemical inputs of the uplands and adjacent estuarine or marine areas. Excessive nutrients and/or toxins in upland and adjacent areas lead to changes in plant and animal populations and to community structure.

Residential and commercial development increases the number of impervious surfaces. This can alter local and regional hydrologic properties by diverting runoff into storm sewers or natural drainages that may be adapted to lower flows. More intense and unpredictable flooding may result, destabilizing the water table and diffusion zone along the below ground fresh water-salt water interface.

Development increases the loss and fragmentation of natural habitats, stressing species with small populations, especially those that require large contiguous habitats, and ones that are intolerant of human contact. Ground disturbance associated with various land uses makes the invasion of exotic plant species more likely.

Resource Consumption

Forestry and groundwater extraction are agents of change in coastal upland areas. The wholesale removal of usable trees (for lumber and agricultural clearing) throughout the forests of the Northeast from the Colonial period through the 19th century caused dramatic changes to both coastal and inland ecosystems. The second and third-growth forests of uplands in the NCBN, and forests in surrounding park watersheds, are not active sites for logging. Probably the most significant resource we currently extract from coastal uplands is the groundwater we require for residential, commercial, and agricultural use. Excessive groundwater extraction can decrease freshwater input to estuarine ecosystems, thereby altering the movement and salinity of estuarine waters.

Visitor and Recreation Use

Coastal uplands in Coastal and Barrier Network parks are affected by park users both directly by the use and creation of trails and informal recreation sites, and indirectly by creating a need for park infrastructure development. For shoreline access, more social trails have been built in heavily used areas of Network parks. Even the use of tailless areas–cliff tops and other sites with dramatic vistas, and shorelines–can degrade and fragment local habitats, altering hydrologic properties. Although park planning policies ensure that potential impacts are assessed before any in-park development occurs, heavy park use necessitates consideration for enhancements to park infrastructure.

2.5.4.2 **Stressors**

Altered Hydrologic Properties

Natural disturbances and differing land uses in coastal uplands can alter runoff, sediment transport, groundwater percolation, the water table, and the below ground interface between fresh and salt water.

Altered Landscape

Changes in land use, the direct consumption of resources, and natural disturbances all result in alterations to landscape patterns and processes. Past logging and recent fire suppression have likely been the primary factors over the past centuries in the overall pattern of forest composition and cover. Habitat fragmentation in and around the NCBN parks continues to disrupt the distribution, abundance, and sometimes even the persistence of native species, while allowing corridors of entry for invasive exotic species. Even small scale changes often lead to critical changes in landscape.

Invasive Species

In Northeast coastal uplands, most threatening invasive exotic species are plant species. Invasive plant species in general are responsive to and responsible for changes in upland ecosystems. Many invasive plants can take advantage of disturbances due to their vegetative and reproductive characteristics, such as rapid growth, clonal growth habit, high seed production, and long distance seed dispersal. Since exotic species are new to an ecosystem, they are often free of the pathogens and consumers from their native habitats. Lacking predators, invasive plants often out-compete native species, reducing plant diversity and the local and regional diversity of wildlife habitats. Some invasive plant species can change the landscape or its ecological processes in their new habitats, for example, by creating dense thickets in the forest understory or altering nutrient cycling in soils.

Altered Sediment Processes

Any changes to hydrologic properties or soils, whether short term, such as a storm event, or long term, such as changed land use or the development of a social trail, can alter the erosion and deposition of sediments, threatening plant and animal populations. For example, both eroding and depositional areas can become vectors for invasive species. Also, erosion of upland areas can alter the water quality and habitat value of adjacent freshwater or coastal wetlands.

Altered Chemical Inputs

Land uses (e.g., development and agricultural uses) alter the chemical inputs into coastal upland ecosystems. Acid precipitation, specifically sulfur dioxide and nitrogen oxides created from power generation and auto emissions, may already be changing forests throughout the Northeast by damaging the leaves of trees and leaching nutrients from soils. Local development and agricultural land use increases the amount of nutrients in soils, streams, and groundwater, thus increasing the likelihood of toxic chemical inputs. Manufacturing, commerce, and urban growth produce industrial chemicals, petroleum, pesticides, sewage, and combustion byproducts. Each of these threatens our ecosystems.

2.5.4.3 **Ecosystem Responses**

Ecosystem Function Changes

The primary productivity of plants in coastal uplands depends on available nutrients, nutrient cycling processes, and the composition of the upland biotic communities. All of the agents of change and stressors to coastal uplands can alter one or more of these factors, and thus, can disrupt productivity. For example, changes in local land use can increase nitrogen inputs into the system through runoff. Also, changes in regional land use can increase atmospheric deposition of nitrogen. But changes in productivity in upland systems do not always reflect changes in the health of the ecosystem. For example, recently disturbed soils tend to release a large pulse of available nitrogen, which is often easily absorbed by fast growing exotic invasive species. In this case, the total productivity of the system increases in the short term, but other indicators (e.g., biodiversity) suggest a less healthy ecosystem.

Similarly, changes in biogeochemical cycling (the movement and transformations of materials in an ecosystem through biological, geologic, and chemical processes and interactions) occur in response to stressors, but do not predict system health in a simple way. For example, fire suppression can alter nutrient cycling by changing the composition of forest floor materials from relatively more live plant matter and more exposed soils to relatively more dead plant material and more shaded soils. The soil microorganisms that mediate nutrient cycling are affected by the changed environment, and the processing of materials and release of nutrients slows when, for example, more large woody debris covers the forest floor. Changes in ecosystem functions usually co-occur with changes in biotic structure and the physical environment.

Biotic Structure Changes

Coastal uplands in the Northeast include numerous forest, shrub and meadow communities, and the birds, mammals, reptiles, amphibians, insects, and microorganisms that depend on these habitats for survival. Stress imposed on coastal uplands alters many aspects of the biological and ecological properties of these organisms. We can easily observe changes in plant growth, plant reproduction, and plant community composition. For example, the understories of many forests in the NCBN parks have been noticeably disturbed by human activities. Invasive exotic species have displaced many native plant species from their habitats.

Changes in the quality of wildlife habitat, whether through alterations to plant communities, land use changes, or other stressors, ultimately affect the composition of wildlife populations and communities. For example, declines in many amphibian populations can be associated with altered chemical inputs and changes to soil chemistry. The degradation of understory vegetation will likely disrupt forest songbird nesting and feeding behavior.

Physical Environment Changes

Many of the stressors to upland ecosystems can lead to changes in topography, hydrologic properties, soil composition, and other physical characteristics such as light conditions and air quality. These changes are reflected in measures of soil compaction along social trails, erosion and sedimentation in drainages, and light penetration to seedlings on a forest floor. These physical characteristics form the structure underlying the ecosystem; thus, changes to the physical environment will also be reflected indirectly by changes to biotic structure and ecosystem functions.

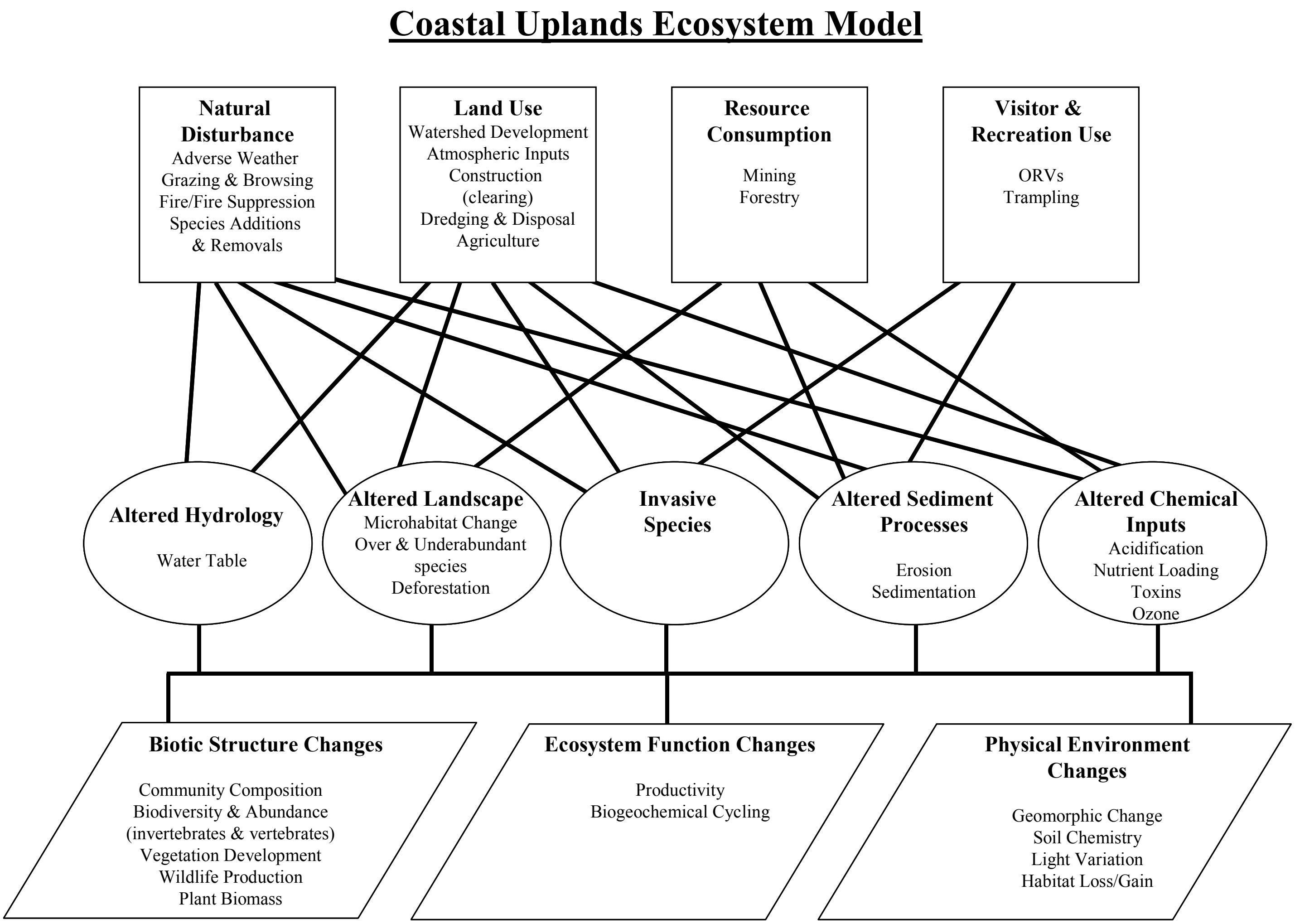

Figure 2.5 Draft NCBN Upland Ecosystem Conceptual Model

2.5.5 Freshwater Ecosystem Model

Only one of the eight parks in the Network–Cape Cod NS–has significant freshwater areas, and these are being monitored as part of the Cape Cod LTEM program. Thus, the Network Technical Steering Committee has decided not to include vital signs for fresh water ecosystems as part of the Network monitoring program. We include a conceptual model depiction for this ecosystem type here for completeness (See Figure 2.6).

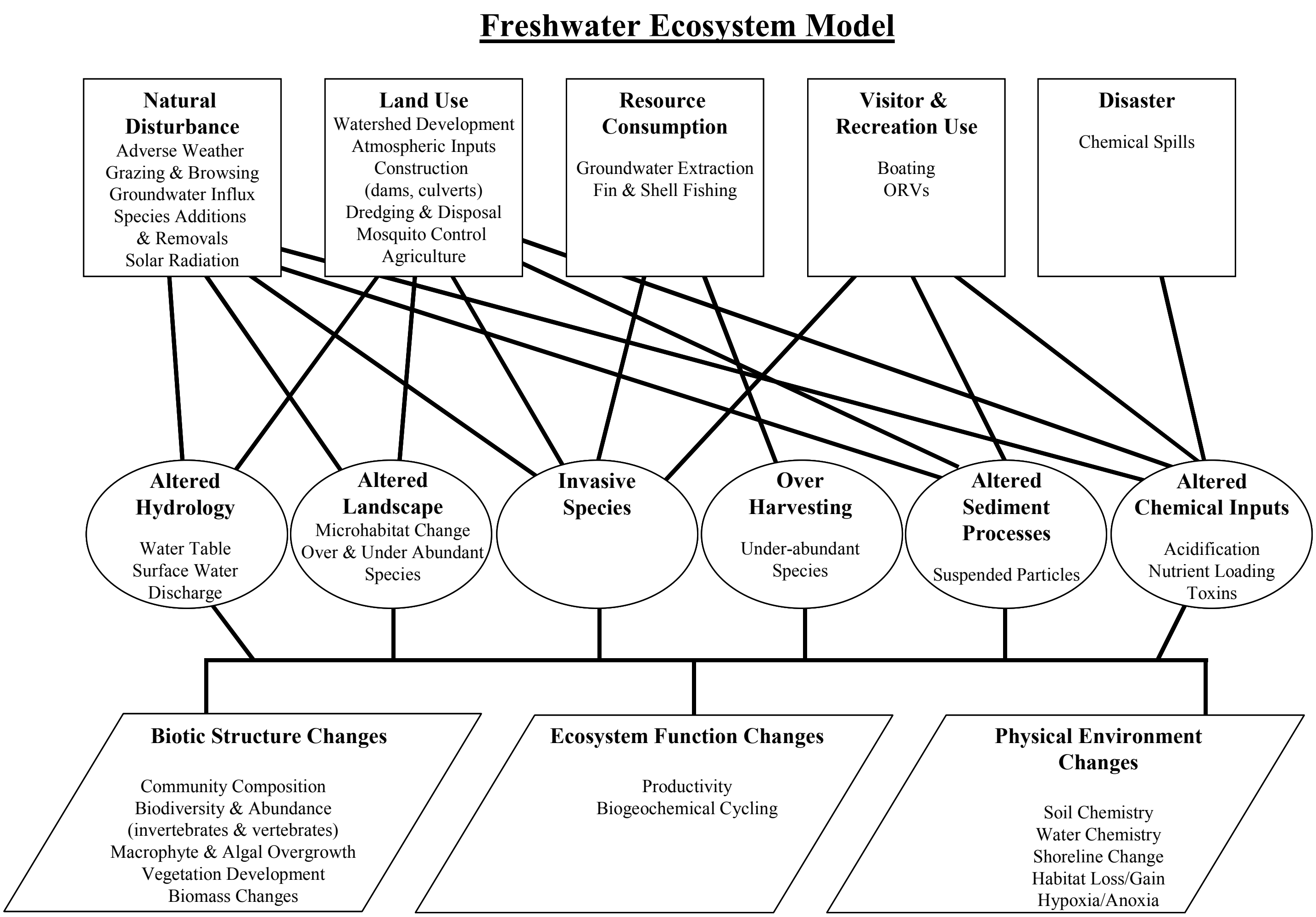

Figure 2.6 Northeast Coastal and Barrier Network Freshwater Ecosystem Model

Chapter 3
Vital Signs

3.1 Final Selection and Prioritizing of Vital Signs Monitoring Projects

Given the high degree of similarity in ecosystem types, processes, and threats among NCBN Parks, the Network has chosen to develop a regional approach to vital signs monitoring. The intent is to choose candidate vital signs and protocols that will be relevant to the collective needs of all parks. Once monitoring begins the Network will be able to assess changing conditions within specific parks and to place these changes in a regional context by comparing trends and values with other parks. This regional approach will be strengthened by seeking ways to collaborate with other Federal, State, and Local agencies developing similar programs.

Based on the guidance provided by the Technical Steering Committee, the scoping workshops, workgroup reports, and project reports (as detailed in Chapter 1), as well as the model provided by the CACO Long Term Ecological Monitoring Program, five major vital signs projects have been developed for NCBN parks: Estuarine Eutrophication Monitoring, Geomorphologic Change Monitoring, Salt Marsh Monitoring, Visitor Impacts Monitoring, and Landscape Change Monitoring.

For each project the Network has followed a workgroup approach to developing an ecosystem-based, issue-oriented vital signs monitoring. The prioritization processes for each project are summarized below and details are available in the appendices. Although the process has varied among workgroups, the most common trajectory has included the establishment of monitoring objectives and questions (see Chapter 1), data mining, and conceptual model development leading to the identification of candidate vital signs. Workgroups were then asked to prioritize the vital signs based on their relevance to management concerns, information content, and feasibility.

In May 2003, the Technical Steering Committee met and reviewed the prioritized list of vital signs. The Committee recommended that a landscape change project be added to the list to address gaps in the upland ecosystem and the species and habitats of concern issue (see Appendix 3.1, *Steering Committee Report_May 2003*). Following this meeting the vital list was revised based on comments received from outside reviewers and the National Inventory and Monitoring program coordinator. The Technical Steering Committee reviewed and approved the final vital signs list (see Table 3.1) in November 2004. Following an independent process the Cape Cod prototype selected additional vital signs to be monitored in their more intensive, park specific monitoring program; these vital signs are listed in Table 3.2.

3.2 Estuarine Nutrients Monitoring

Approximately one quarter of the NPS land area within the Coastal and Barrier Network is submerged. These estuaries, bays, and lagoons serve as islands of relatively pristine aquatic habitat within the northeastern urban corridor. The North Atlantic coastal parks are dependent on high-quality aquatic resources to sustain the complex estuarine and near shore ecosystems they represent. Diverse threats to NPS estuaries exist, including natural disturbances (e.g.

storms, sea-level rise), direct impacts of human activities (e.g. fishing, boating, dock construction), indirect effects of watershed development, and disasters (see Chapter 2). Of these, park managers throughout the Network have repeatedly identified threats to coastal water quality as one of their highest priority management issues (see Appendix 3.2, *NCBN Monitoring Plan_CACO Prioritization Report_Phillips_2003*). Much of the watershed area of NPS coastal ecosystems lies outside protective park boundaries and is subject to intense developmental pressures. Therefore, there is great potential for human disturbances to coastal watersheds to result in increased nutrient loading to park estuaries.

Estuaries can generally assimilate some degree of enrichment without major ecological ramifications, but excessive nutrient inputs typically lead to dense blooms of phytoplankton and fast-growing macroalgae, loss of sea grasses, and decreased oxygen availability in sediments and bottom waters. Ultimately, cascading effects include changes in the species composition and abundance of invertebrates, decline in fish and wildlife habitat value, and the collapse of fin- and shellfish stocks. Protecting the ecological integrity of park estuaries depends on implementing a scientifically-based monitoring program that is capable of diagnosing local causes of nutrient enrichment, detecting changes in nutrient loads, and determining if nutrient inputs are near to exceeding thresholds that would result in shifts in ecosystem structure and function.

An estuarine nutrients workgroup was formed during the Network scoping workshop and they began the work of developing a conceptual model and identifying candidate vital signs. Since many state, local, and federal agencies are already involved in monitoring water quality in the estuaries of the Northeast coast. The workgroup was also given the task of identifying existing sources of monitoring data. Upon receipt of a detailed report (see Appendix 3.3, *in development*) the Network funded a project to prioritize the extensive list of vital signs. Individual potential variables were evaluated in terms of established characteristics of effective monitoring variables (see Table 3.3). Some variables were eliminated because they were difficult or costly to measure (e.g. nutrient loading, de-nitrification rates, agricultural runoff), others because they exhibit high variability (e.g. macro-algal density, dissolved nutrient concentrations), and still others because the predictability of their relationship to nutrient enrichment is still being researched (e.g. index of biotic integrity, indicator species) or is unknown (fecal indicator bacteria).

The most effective monitoring programs include variables that span levels of ecological organization (organisms to landscapes), relationships (causes of and responses to stress) and complexity (structure, function, and composition). Consequently, each variable was also evaluated in terms of its relative contribution to a collective suite, with the goal of including representatives of different scales, trophic levels, and relationships to nutrient enrichment. Finally, potential variables were evaluated for consistency with two NPS programs also under development (national water quality monitoring in marine/estuarine waters; water quality inventory protocols for estuarine/marine systems), and with the long-standing Environmental Monitoring and Assessment Program / National Coastal Assessment of the US Environmental Protection Agency.

Thus, the final list of candidate indicators (see Table 3.1) for this protocol was influenced by both scientific and practical considerations. The vital sign associated with land use change was selected for inclusion because data are available from existing sources and analyses can be made on past, current, and (later) future conditions. Vital signs associated with water quality measure ecosystem responses to eutrophication and are excellent surrogates for the stressors (i.e, nutrient inputs) themselves. Perhaps the single greatest indicator of water quality health is the distribution and abundance of submerged aquatic vegetation (SAV). SAV integrates problems seen at all levels and is true biotic indicator of water quality. State SAV mapping programs exist for all parks.

3.3 Salt Marsh Monitoring

Salt marshes are important habitats in Coastal and Barrier Network Parks and the scoping process has identified salt marsh habitat loss as a major issue. Salt marsh communities serve as biological indicators of the overall ecological health of the parks because they integrate problems and processes associated with salt marsh, estuary and upland ecosystems. They're importance is also recognized by the Cape Cod prototype (see Appendix 27 where monitoring protocols have already been developed by Roman *et al.* (2001; Appendix 17) and Raposa and Roman (2001; Appendix 16) to monitor salt marsh vegetation and Nekton.

These protocols have been implemented at Cape Cod N.S. and eleven Fish and Wildlife Refuges along the Northeast Coast. In addition to these established protocols, the Cape Cod N.S. and the Network are working with Don Cahoon (USGS) to develop and implement a protocol for monitoring Salt Marsh Elevation. Marsh elevation is an excellent integrator of the agents of change and stressors shown in the Salt Marsh Conceptual (Chapter 2) and has direct relevance to sea-level rise. Since marsh elevation is currently being measured at Cape Cod N.S., Fire Island N.S., and Gateway N.R.A. with "Surface Elevation Tables" (see http://www.pwrc.usgs.gov/resshow/cahoon/) the Technical Steering Committee recommended including this vital sign in the salt marsh monitoring program. The vital signs for this program are listed in table 3.1.

3.4 Shoreline Change Monitoring

Monitoring shoreline change has been consistently chosen as a high priority monitoring issue for the coastal parks. Intense anthropogenic activities such as dredging, shoreline protection, and beach nourishment have disrupted geomorphologic processes resulting in dramatic alteration of natural patterns of sedimentation and accretion. Existing problems are further compounded by global climate change and sea level rise. As a result, parks are witnessing accelerating loss of natural, cultural, and recreational resources (Appendix 18).

The Network approach to developing a shoreline change program relies heavily on existing monitoring programs that are being developed for Assateague Island N.S., Gateway N.R.A., Fire Island N.S. and Cape Cod N.S. Most of these programs involve GPS mapping of the shoreline. Recently, collaborative arrangements with Wayne Wright of NASA and John Brock of the USGS have allowed the Network to utilize aircraft based LIDAR (LIght Detection And Ranging) to gain a more detailed understanding of topographic changes to islands and beaches for more information see Appendix 18.

Information gained from existing programs coupled with scoping to determine park needs have been evaluated in a series of workshops. The goals of the meetings were to identify key scientific issues, information gaps, and long-term data relevant to coastal geomorphologic change and to identify a list of indicators or vital signs for monitoring shoreline change.

Workgroups composed of scientists, natural resource managers, and technical professionals from federal agencies, universities, and parks met at the following locations:

- USGS Patuxent Wildlife Research Center (February 1999; Appendix 12)
- Gateway National Recreation Area (April 2000; Appendix 14)
- USGS Woods Hole Field Center (January 2001; Appendix 22)
- University of Rhode Island Coastal Institute (October 2002; Appendix 18)

The Gateway and Woods Hole workshops focused their attention primarily on ocean shorelines and developed general feature categories for monitoring. The URI workshop, in addition to reviewing the results and recommendations of the previous meetings, also addressed the lower energy estuary issues and was much more exhaustive, detailed and specific regarding the identification of monitoring variables. The URI group went on to generate a lengthy list of potential variable indicators or vital signs and to prioritize them based on feasibility and information content (Appendix 18). Vital signs that gave good indications of the horizontal position of the shoreline and general beach and dune topography were selected for monitoring (Table 3.1). Additional vital signs related to geomorphology, hydrography, and anthropogenic modification were considered necessary for a deeper understanding of the processes involved (Table 3.1).

3.5 Visitor Impact Monitoring

Visitor impacts to coastal resources are a significant concern to resource managers in all Network Parks. The degree of concern and the potential for significant impact, however, is highly area dependent. For example, Gateway National Recreation Area, located in the New York City metropolitan area, sees over 8 million visits per year, with many visitors engaged in traditional beach activities such as swimming, sunbathing and sport fishing. In many cases, the popular sites for many of these activities are in proximity of areas managed for high resource protection. Conversely, at Sagamore Hill National Historic Site the majority of visits occur in the museum facilities, with very little current activity on the trails and the small barrier island area. Given these differences, the visitor impacts workgroup recommended that comprehensive scoping be completed for each park (Appendix 14).

Individual scoping workshops and site visits were conducted for every park beginning in 2001. The goal of this work was to establish baseline conditions, review existing monitoring, and develop a list of candidate vital signs. This phase of the project was completed and report written in the Spring of 2003 (Appendix 21). The candidate vital signs were then prioritized. The selection of accurate and appropriate vital signs of visitor use and resource impacts is essential to the development of any program of long-term monitoring.

For the visitor impact monitoring project, a three-step process was used to select and prioritize vital signs. First, conceptual models of the interactions of agents of change, stressors and ecosystem responses were developed for visitor impacts in coastal ecosystems and for the soil, vegetation and wildlife responses within those ecosystems (Appendix 25). This conceptual model approach is helpful to illustrate the mechanisms of impact and the ecosystem-level consequences of those impacts. Second, candidate vital signs were identified based on the conceptual models and the scoping results. Finally, candidate vital signs were evaluated against thirteen selection criteria derived from a literature review (Table 3.4). A matrix approach was used to assign each vital sign a numerical rank. The results are presented as a prioritized list of candidate vital signs (Appendix 25).

The scoping process revealed that park managers were most interested in measurements related to the park use and this vital sign was ranked high and by the prioritization process. Resource impact vital signs (Habitat Alteration, and Wildlife Disturbance) were also ranked highly, however, it was difficult to define measurements for these vital signs that could be realistically developed into monitoring protocols (see Table 3.1 and Appendices 21 and 25).

The Technical Steering Committee reviewed of this project (Appendices TSC 2003 and 2004) accepted the vital signs but indicated that further refinement was necessary before protocol development could begin. A workshop has been organized for January 2005 to address this issue. The workshop will review the work that has been completed for this project, redefine the objectives and monitoring questions, and develop a written a scope of work for protocol development. The Network anticipates that protocol development will begin shortly thereafter.

3.6 Landscape Change Monitoring

The final vital sign, landscape change (Table 3.1), was proposed by the Technical Steering Committee (TSC report 2003) to address a major gap in the monitoring program. Most efforts to date have concentrated on shoreline, estuaries, and salt marshes with little attention given to upland areas. Data mining recommended by the species and habitats of concern workgroup resulted in a comprehensive report on vertebrate monitoring programs in and around Network parks (Appendix 20) but did not lead to any definitive issue-based monitoring questions. The technical steering committee discussed the Network's needs for upland areas and recommended monitoring landscape change. Vegetation maps are being developed for all Network parks and will be complete by 2005. The steering committee recommended the formation of a workgroup to examine the feasibility of using the vegetation maps as a baseline for continued monitoring of landscape change.

The inclusion of land cover change as a vital sign is desirable because it will provide information on all five major ecosystems of the Network and will be relevant to the Networks all of the Networks major issues (see Chapter 1). As a first step, a project was initiated with Dr. Y.Q. Wang (University of Rhode Island) to investigate whether Satellite data could be used to define habitat or land cover classes from the newly complete vegetation map for Fire Island N.S. and to produce a protocol for change detection analysis. If successful, this will allow the Network to develop a cost effective program of landscape change monitoring.

Following the completion of Phase II of the vital signs monitoring plan by the first twelve inventory and monitoring Networks in October 2003 the National I&M program compiled a list of the vital signs selected. Land use/ land cover change was the most commonly selected vital sign. Given the overwhelming interest in this vital signs by the Networks a workgroup was created by the National program to explore ways to develop protocols for land use/land cover change monitoring by the Networks. The Network and its collaborator Dr. Wang are participating in the effort. As a result, the Network decided to delay protocol development until the results of this workgroup were available. This decision was accepted by the Technical Steering Committee (TSC Nov2004 Appendix).

3.7 Vital Signs for Water Quality

Network park perennial waters include a small number of ponds, several rivers and streams, and extensive coastal waters. Many of these waters are impaired in some way, most commonly by the suite of impairments associated with nutrient enrichment, but also in some cases by PCBs, acidity, heavy metals, or pathogens, including fecal coliform bacteria (see Table 3.5 and Final Water Quality Report).

Estuarine waters, whether in coastal embayments or lower reaches of rivers, make up the bulk of Network park waters, and most other park waters are rivers and streams that drain into estuaries. The principal impairments to these estuaries are those associated with nutrient enrichment, including dissolved oxygen, organic enrichment, and nutrients. These impairments are addressed through the Estuarine Eutrophication Monitoring project.

Direct sampling of the estuaries at Network parks will provide information on ecosystem responses that are closely linked to nutrient levels. These are reflected in six vital signs - Estuarine Water Chemistry, Estuarine Water Quality, Estuarine Water Clarity, Seagrass Distribution, Seagrass Condition, and Estuarine Sediment Organic Carbon (Table 3.1). A seventh sign, Estuarine Nutrient Inputs, from the “agents of change” component of the project will provide estimates of past and present nutrient inputs into park estuaries (Table 3.1).

In addition to the Network-wide estuarine nutrients monitoring, the Cape Cod Prototype Monitoring Program includes additional vital signs monitoring related to impaired waters. Monitoring of nutrient inputs into marine, estuarine and freshwater areas occurs via Groundwater Nitrates and Groundwater Quality vital signs, as well as the Air Chemistry - Nitrogen / Sulfur Deposition vital sign. Also, Cape Cod NS is unusual among Network parks for containing numerous kettle ponds, and monitoring of these ponds is ongoing through Kettle Pond Acidification and Kettle Pond Nutrient Loading and Eutrophication vital signs (Table 3.2).

Also, monitoring programs through EPA, state, and/or Network parks is ongoing for the Water Chemistry vital sign at seven Network parks, and for the Water Quality (toxics, microorganisms, macro-invertebrates and algae) vital signs at six of the Network parks. (For a complete listing of ongoing programs, see the Vital Signs Framework document/database.)

Table 3.2 shows additional Vital Signs chosen for monitoring by the Cape Cod N.S. For each vital sign defined by the Prototype (CACO Vital Sign) the corresponding Level 1, 2 and 3 categories from the National Inventory and Monitoring Program Hierarchical Vital Signs Framework are given along with proposed measurements.

Table 3.1 Vital Signs chosen for monitoring by the Northeast Coastal and Barrier Network (NCBN). For each vital sign defined by the Network (NCBN Vital Sign) the corresponding Level 1, 2 and 3 categories from the National Inventory and Monitoring Program Hierarchical Vital Signs Framework are given along with proposed measurements and a list of Parks where the protocols will be implemented

NCBN Project	National Vital Signs Hierarchy			Northeast Coastal and Barrier Network		Park							
	Level 1	Level 2	Level 3	Vital Sign	Measurements	ASIS	CACO	COLO	FIIS	GATE	GEWA	SAHI	THST
Estuarine Eutrophication	**Water**	Water Quality	Water chemistry	**Estuarine Water Chemistry**	Dissolved Oxygen,Temperature, Salinity	X	X	X	X	X	X	X	
	Water	Water Quality	WQ Nutrients	**Estuarine Water Quality**	Chlorophyll a	X	X	X	X	X	X	X	
	Water	Water Quality	Water chemistry	**Estuarine Water Clarity**	Photosynthetically Active Radiation (PAR), Turbidity	X	X	X	X	X	X	X	
	Biological Integrity	Focal Species or Communities	Marsh/Estuary communities	**Seagrass Distribution**	Submerged Aquatic Vegetation (SAV) bed size, structure and location.	s	X	X	X	X	X	X	
	Biological Integrity	Focal Species or Communities	Marsh/Estuary communities	**Seagrass Condition**	Submerged Aquatic Vegetation (SAV) within bed, percent cover, shoot density, and biomass.	X	X	X	X	X	X	X	
	Geology and Soils	Soil Quality	Soil function and dynamics	**Estuarine Sediment Organic Carbon**	Percent organic carbon of surficial sediments	X	X	X	X	X	X	X	
	Ecosystem Pattern and Processes	Land Cover and Use	Land cover and use	**Estuarine Nutrient Inputs**	Nutrient point source discharge permits, livestock populations, fertilizer consumption, permitted water withdrawals for domestic and agricultural consumption, wet deposition N chemistry	X	X	X	X	X			
Geomorphologic Change	**Geology and Soils**	Geomorphology	Coastal / oceanographic features and processes	**Shoreline Position**	Shoreline Position	X	X		X	X			
	Geology and Soils	Geomorphology	Coastal / oceanographic features and processes	**Coastal Topography**	Dune, Cliff & Bank Features, Shore Type, Overwash fans/flood plain, Landscape Pattern, Edge of Vegetation	X	X	X	X	X	X	X	
	Geology and Soils	Geomorphology	Marine features and processes	**Marine Geomorphology**	Bathymetry, Location of migrating shoals and bodies, sediment size & type	X	X	X	X	X	X	X	
	Water	Hydrology	Marine hydrology	**Marine Hydrography**	Current patterns, Sea Level Position, Tide Range, Wave Characteristics	X	X	X	X	X	X	X	
	Ecosystem Pattern and Processes	Land Cover and Use	Land cover and use	**Anthropogenic Modifications**	Locations of jetties, shoreline armoring, dredge channels, beach nourishment sites, dune manipulations, etc.	X	X	X	X	X	X	X	
Salt Marsh	**Biological Integrity**	Focal Species or Communities	Marsh/Estuary communities	**Saltmarsh Vegetation Community Structure**	Percent Cover, Species Composition	X	X	X	X	X	X	X	
	Biological Integrity	Focal Species or Communities	Marsh/Estuary communities	**Saltmarsh Nekton Community Structure**	Species composition, Abundance, Size Structure	X	X	X	X	X	X	X	
	Geology and Soils	Geomorphology	Coastal / oceanographic features and processes	**Salt Marsh Sediment Elevation Change**	Relative elevation, sediment accretion	X	X	X	X	X			
Visitor Impacts	**Human use**	Visitor and Recreation Use	Visitor usage	**Park Usage**	Park use type, park use density, park use distribution	X	X	X	X	X	X	X	X
	Human use	Non-point Source Human Effects	Non-point source human effects	**Habitat Alternation**	Number and distribution of social trails and unofficial recreation sites, amount of newly exposed soil, amount of damage to bottom communities from anchoring and mooring,	X	X	X	X	X	X	X	X
	Human use	Non-point Source Human Effects	Non-point source human effects	**Wildlife Disturbance**	Disturbance type, Disturbance time, Attraction Behavor	X	X	X	X	X	X	X	X
Landscape Change	**Ecosystem Pattern and Processes**	Land Cover and Use	Land cover and use	**Landscape pattern**	Habitat cover type area, patch size distribution, patch density, framentation, and isolation	X	X	X	X	X	X	X	X

Table 3.2 Additional Vital Signs chosen for monitoring by the Cape Cod N.S.

National Vital Signs Hierarchy			Cape Cod National Seashore	
Level 1	**Level 2**	**Level 3**	**Vital Sign**	**Measurements**
Air and Climate	Air Quality	Air contaminants	**Air Chemistry - Contaminants**	Volatile organic chemical concentrations (benzene, toluene, ethylene chloride), Hg
Air and Climate	Air Quality	Ozone	**Air Chemistry - Ozone**	Atmospheric ozone concentration
Air and Climate	Air Quality	Visibility and particulate matter	**Air Chemistry - Fine Particles**	Atmospheric particulate concentrations (SO4, NO3), elemental and organic carbon, NH4
Air and Climate	Air Quality	Visibility and particulate matter	**Visibility**	IMPROVE monitoring
Air and Climate	Air Quality	Wet and dry deposition	**Air Chemistry - Nitrogen / Sulfur Deposition**	Wet deposition chemistry (pH, NO3-, SO4=), continuous sulfur (SO2) dioxide concentrations
Air and Climate	Weather and Climate	Weather and Climate	**Weather**	Precipitation amount and duration, temperature, wind speed and direction, total and net solar radiation, PAR, relative humidity
Biological Integrity	Focal Species or Communities	Amphibians and Reptiles	**AquaticTurtles**	species occurrence, abundance, distribution
Biological Integrity	Focal Species or Communities	Amphibians and Reptiles	**Anurans**	species occurrence (egg mass presence, calls), relative abundance (call count indices)
Biological Integrity	Focal Species or Communities	Amphibians and Reptiles	**Salamanders**	species occurrence, abundance (egg mass counts)
Biological Integrity	Focal Species or Communities	Aquatic vegetation	**Pond Vegetation**	species composition, %cover
Biological Integrity	Focal Species or Communities	Aquatic vegetation	**Vernal Wetland Vegetation**	species composition, %cover
Biological Integrity	Focal Species or Communities	Birds	**Land Birds**	species occurrence, abundance, distribution
Biological Integrity	Focal Species or Communities	Birds	**Marsh Birds**	species occurrence, abundance
Biological Integrity	Focal Species or Communities	Birds	**Migrating Waterbirds**	species occurrence, abundance, distribution
Biological Integrity	Focal Species or Communities	Fishes	**Freshwater Fish**	species composition, size class structure
Biological Integrity	Focal Species or Communities	Forest vegetation	**Coastal Forest Vegetation - Shrub/Herbaceous Layers**	species composition, cover
Biological Integrity	Focal Species or Communities	Forest vegetation	**Coastal Forest Vegetation - Trees**	species composition, density, basal area, canopy cover, recruitment, health (index)
Biological Integrity	Focal Species or Communities	Freshwater invertebrates	**Freshwater Aquatic Invertebrates**	species composition, abundance
Biological Integrity	Focal Species or Communities	Intertidal communities	**Beach Macroinvertebrates**	species composition, distribution, density
Biological Integrity	Focal Species or Communities	Mammals	**Meso-Mammals**	species occurrence, abundance, distribution
Biological Integrity	Focal Species or Communities	Mammals	**Small Mammals**	abundance, survival, community structure, diversity, distribution
Biological Integrity	Focal Species or Communities	Marsh/Estuary communities	**Estuarine Benthic Macrofauna**	species composition, distribution, density
Biological Integrity	Focal Species or Communities	Vegetation communities	**Coastal Heathland Vegetation**	species composition, % cover
Biological Integrity	Focal Species or Communities	Vegetation communities	**Dune Grassland Vegetation**	species composition, %cover
Geology and Soils	Soil Quality	Soil function and dynamics	**Estuarine Sediment Solid Phase Properties**	grain size distribution, % organics by weight;
Human use	Point-Source Human Effects	Non-point source human effects	**Contaminants**	location, type, and persistence of contamination, ecological risks
Water	Hydrology	Groundwater dynamics	**Groundwater Dynamics**	Depth to groundwater, well recharge rate
Water	Hydrology	Surface water dynamics	**Surface Water Dynamics**	pond stage, tidal creek discharge
Water	Water Quality	Water chemistry	**Ground-Water Quality**	nutrients, major ions, alkalinity, pH, DO, dissolved organic carbon
Water	Water Quality	Water chemistry	**Kettle Pond Acidification**	temperature, pH, alkalinity, Mg, K, Na, Ca
Water	Water Quality	WQ Nutrients	**Estuarine Nutrients**	TN/TP, orthophosphate, nitrate, ammonium, PAR, Secchi disk depth, DO, temperature, salinity, pH
Water	Water Quality	WQ Nutrients	**Ground-Water Nitrates (Estuarine Input)**	TN/TP, orthophosphate, nitrate, ammonium, temperature, salinity, pH
Water	Water Quality	WQ Nutrients	**Kettle Pond Nutrient Loading and Eutrophication**	temperature, conductivity, DO, light penetration, Secchi depth, TN/TP, orthophosphate, nitrate, ammonium, SO4, Cl

Table 3.3 Characteristics of effective monitoring variables (after Jackson *et al*. 2000, Dale and Beyeler 2001, Kurtz *et al*. 2001; see also Appendix 24).

Characteristics of Effective Monitoring Variables
Relevant to management concerns and ecological resources
Address monitoring questions of interest
Have known linkage to ecological function or critical resource of interest
Are at appropriate scale to answer specific monitoring questions
Are integrative in space and time, so that the full suite of variables provides assessment of entire system of interest
Applicable for use in a monitoring program
Are easy and practical to measure
Are non-destructive or low impact to measure without disturbing monitoring site
Are measurable using standard, well-documented methods
Generate data that are compatible with other systems
Are cost-effective to measure
Responsive to anthropogenic stresses
Have known sampling and measurement error
Have low natural variability
Have known variability in time and space
Are sensitive to anthropogenic stresses on the system or resource of interest, while having limited and documented sensitivity to other factors (i.e. to natural variation in ecosystem condition)
Interpretable and useful to environmental decision-making
Respond to stress in a predictable manner
Are anticipatory: signal impending change in ecosystem before substantial degradation occurs
Are linked to management decisions; predict changes that can be averted by management action, or document success of past actions
Have known or proposed thresholds of response that delineate acceptable from unacceptable ecological condition
Can be communicated to managers and the public

Table 3.4 Evaluation criteria for visitor impact vital signs. The first four criteria are required while the remaining nine are desirable criteria. These criteria were adapted from Belnap (1998), Consulting and Audit Canada (1995), GYWVU (1999) and Manning *et al.* (*in prep*).

CRITERIA	DESCRIPTION
Low measurement impacts	The indicator can be measured with no or minimal level of ground disturbance
Reliable/Repeatable	The measurements of indicator by different field staff would show reasonable agreement
Correlation with use	The indicator is directly related to visitor use with good level of correlation
Ecologically relevant	The indicator must have conceptual relevance to concerns about ecological condition, i.e., it must be a component of the appropriate conceptual model. It must reflect an important change of resource condition that would lead to significant ecological or social consequences
Respond to impacts	Change of resource condition can occur promptly after impacts are introduced
Respond to management	Resource conditions can be manipulated by management actions
Easy to measure	Field measurements are relatively straightforward to perform with minimal level of equipment needed
Low natural variability	Indicator has a limited level of spatial and temporal variability
Large sampling window	Field measurements can take place in most of the times in a year
Cost effective	Measurements of indicator are inexpensive. Little additional cost to management. Data gathered benefit management
Easy to train for monitoring	Field staff with no prior knowledge of field procedures can be easily trained to perform such procedures
Baseline data	There are existing data on the indicator, preferably with the use-impact link established
Response over different conditions	Impacts can be seen while still relatively slight

Table 3.5 Pollutants Identified as Impairments to Network Park Waters

Impairments listed include those found in waters both within and adjacent to parks. Source: EPA and state water quality reports, as summarized in James-Pirri, M.J. (2004), Wetland and Water Quality Issues for Parks of the Northeastern US: A Scoping Report for the Coastal Barrier Network. For the full list of impairments to specific water bodies, see report.

	Park							
Pollutant	ASIS	CACO	COLO	FIIS	GATE	GEWA	SAHI	THST
Nutrients	X	X	X		X	X		X
Dissolved Oxygen	X	X	X		X	X		
Organic Enrichment		X	X		X	X		
Suspended Sediment						X		X
Pathogens	X	X	X	X	X	X	X	
Fecal Coliform	X		X		X	X		
PCBs			X		X	X	X	
Pesticides					X			
Chlordane					X			
Metals		X			X			
Acidity		X						

Chapter 4
Sampling Design

Sampling design guides and determines the entire process of deciding where, when, and how often to sample (Fancy 2000; Elzinga et al 2001). An appropriate and useful sampling framework is crucial to the success of any monitoring program, as shown in a limited review by Reid (2001). In that study, 13% of flawed monitoring programs failed due to problems associated with sample design.

The National Inventory and Monitoring program has provided extensive guidance on how to develop spatially balanced sampling schemes (see http://science.nature.nps.gov/im/monitor/vsmTG.htm). Although many of the National I&M design guides are associated with large parks where access is limited (e.g., McDonald & Geissler 2004), these balanced sampling schemes can be useful guides. Northeast Coastal Parks range in size from 33ha to 19,200ha (see Table 1.1). Therefore, these parks are small enough for complete surveys of all spatial units within each park for some vital signs. But not for others– some protocols require a probabilistic approach to sample site selection.

Table 4.1 shows a summary of these spatial and temporal sampling designs for the Network Vital Signs Monitoring Program. Each protocol a follows a distinct sampling design that is consistent with National Inventory and Monitoring Program's guidelines. For each protocol, decisions such as whether or not to use permanent or temporary plots depend on the unique characteristics of the ecosystems involved.

A detailed understanding of the highly dynamic nature of the shifting sand ecosystems must be included in the sampling design for Northeast Coastal Parks. Depositional and erosional processes affecting these sites can result in geomorphologic change that occurs on ecologically relevant time scales. As an extreme example, Assateague Island was separated from Fenwick Island by the hurricane of 1933. Subsequent engineering projects initiated to protect the new inlet accelerated the inland migration of Assateague Island. As a result, parts of Assateague Island N.S. are no longer included in the original legislative boundary.

The Network's monitoring program will emphasize ecosystem-based sample designs which are protocol specific to ensure high quality sampling. The sampling design for each protocol will be determined by monitoring objectives and questions (see Chapter 1 for details) and corresponding vital signs and measures (see Chapter 3 for details).

4.1 NCBN Sampling Approach

Vital signs are central to how the Network creates specific sampling designs. Vital signs inform us about the physical, chemical, and biological elements and processes within park ecosystems. Methods used to measure Vital signs vary from ecosystem to ecosystem. Thus, the Network has created an array of spatial and temporal sampling designs based on specific protocols and vital signs within those ecosystems (see Table 4.1).

Table 4.1 Summary of the spatial and temporal sampling designs for the Network Vital Signs Monitoring Program

	Vital Sign	Spatial Sampling Design	Temporal Samping Design
Estuarine Eutrophication	**Estuarine Water Chemistry**	A grid of 30 tessellated hexagons is overlain on the estuarine area of interest; sampling occurs at a random location in each hexagon.	Yearly during a summer four-week index period.
	Estuarine Water Quality	A grid of 30 tessellated hexagons is overlain on the estuarine area of interest; sampling occurs at a random location in each hexagon.	Yearly during a summer four-week index period.
	Estuarine Water Clarity	A grid of 30 tessellated hexagons is overlain on the estuarine area of interest; sampling occurs at a random location in each hexagon.	Yearly during a summer four-week index period.
	Estuarine Sediment Organic Carbon	A grid of 30 tessellated hexagons is overlain on the estuarine area of interest; sampling occurs at a random location in each hexagon.	Once every five years.
	Seagrass Distribution	Complete surveys of all seagrass beds in and around park units.	Once every five years.
	Seagrass Condition	Representative SAV bed chosen; One 50-m transect is located within each of three depth zones (shallow, mid-depth, and deep); twelve sampling locations are then randomly positioned along each transect.	One to four times a year.
	Estuarine Nutrient Inputs	Complete surveys of park and area surrounding area of interest.	Once every ten years.
Geomorphologic Change	**Shoreline Position**	Complete survey of ocean park shorelines.	Two times per year and following major storm events.
	Coastal Topography	Complete survey of shoreline beach/dune habitats.	Every other year.
	Marine Geomorphology	Complete survey of parks and surrounding areas.	To be determined.
	Marine Hydrography	Complete survey of parks and surrounding areas.	To be determined.
	Anthropogenic Modifications	Complete survey of parks and surrounding areas.	To be determined.
Salt Marsh	**Saltmarsh Vegetation Community Structure**	Salt Marsh habitat stratified based on distance to inlets; study marshes selected randomly from available sites within strata; study marshes are stratified based on physical factors; strata are systematically subdivided and transects randomly placed in each division along ecological gradients; plots are evenly spaced along transects from a random starting point.	Every three years.
	Saltmarsh Nekton Community Structure	Study marshes chosen for Salt Marsh Vegetation monitoring will be also be used for Nekton Monitoring; various methods will be used to randomly select pools and ditches to be sampled.	Each park sampled every three years during early and late summer. Samping is tide cycle dependent.
	Salt Marsh Sediment Elevation Change	Existing sites will be maintained and new ones added to marshes chosen for Salt Marsh Vegetation and Salt Marsh Nekton Monitoring.	3 times per year initially, may be reduced to once a year
Visitor Impacts	**Park Usage**	To be Determined: Considering th use of grid design with random starts or stratifying parks by habitat type & use.	To be determined
	Habitat Alternation	To be Determined: Considering th use of grid design with random starts or stratifying parks by habitat type & use.	To be determined
	Wildlife Disturbance	To be Determined: Considering th use of grid design with random starts or stratifying parks by habitat type & use.	To be determined
Landscape Change	**Landscape pattern**	Complete survey of all aquatic and terrestrial habitats	To be determined; every 5-10 years?

To insure continuity among projects and consistency in data collection and analysis, the Network adheres to the sample design guidelines of the National Inventory & Monitoring program (http://science.nature.nps.gov/im/monitor/vsmTG.htm). Use this site to acquire general design ideas and a broad perspective about overall sampling design.

4.2 NCBN Sampling Guidelines

The NCBN sampling approach strives for unbiased, reliable, and appropriate sampling designs. Because the ecosystems within the Network parks are so diverse, many designs are possible and appropriate for sampling.

4.2.1 Selection of Sample Sites

Complete spatial surveys of all areas of interest provide the most reliable data for monitoring. For programs that use remote sensing to measure vital signs, complete surveys are an option. Data can be collected at spatial scales set to incorporate the entire area of interest. Examples of this include the landscape pattern, seagrass distribution, and coastal topography vital signs (see Table 4.1); the only ground-based program that will include a complete survey is the shoreline position protocol.

When a complete survey is not possible, *probability sampling* is used to ensure that sample site selection is unbiased (see Elzinga et al 2001). In probabilistic designs, every element in the area or population of interest has a known chance of being sampled, and sampling includes a random component. With a statistically valid probabilistic design, monitoring data can help us make inferences about areas within the park that have not been sampled (Fancy 2000). Study sites for the majority of the vital signs to be monitored are selected this way (see Table 4.1).

Spatially balanced sampling designs are used to insure that sample units are spread evenly over the area of interest to avoid clumping that can result from simple randomization with low sample sizes (Geissler 2001; McDonald & Geissler 2004).

The Network's Vital Signs Monitoring programs use a variety of methods for distributing sample sites. Examples include:

- *Stratified designs* based physical features of the environment are used to distribute sample sites among recognizable subunits of ecosystems or habitats. The National Program (see Fancy 2000) recommends that the vegetation maps not be used as a basis for stratified designs as boundaries among vegetation classes may change over time; physical characteristics such as elevation, slope and aspect are preferred. Stratified designs are used by the Network to identify broad habitat areas for locating addition sample units. An example of this is the selection of individual salt marshes for intensive vegetation and nekton monitoring. In this case, suitable sized patches of contiguous habitat are identified and stratified based on distance to inlets to insure that the full range of tidal influences that occur between exposed and interior marshes are included in surveys.

- A *grid design* with a random starting point is an effective technique of selecting spatially distributed random sample sites. This method is used to select individual sample sites within salt marshes for vegetation sampling (Roman et al 2001). A larger grid based approach may prove useful for the visitor impact monitoring program as well.
- A *randomized-tessellation stratified design* adapted from the Environmental Protection Agency National Coastal Assessment (US EPA 2001) is used to select water quality monitoring sites for estuarine nutrients monitoring. This design results in a set of samples that is balanced spatially over the entire estuary of interest.

Because this sampling protocol is consistent with the EPA National Coastal Assessment, the condition of park estuaries can be evaluated within the context of other estuaries in the region and vital signs data can contribute to overall regional assessments.

Although strongly discouraged, limited use of *judgment sampling*, the choice of representative sites based on "best professional judgment" is permitted in situations where logistical limitations preclude a probabilistic design or when existing programs are incorporated into the Network's monitoring plan (Elzinga et al 2001). In these rare cases, information gained will only be used to address specific questions about status, condition, or cause of change and inferences will be limited to the area sampled.

In the salt marsh sediment elevation protocol, for example, the Network will work with existing monitoring sites that have been established in Fire Island N.S., Gateway N.R.A. and Cape Cod N.S. Additional sites to be added at Assateague Island N.S., Colonial N.H.P., and George Washington Birthplace N.M. will be collocated with salt marsh vegetation and nekton sites if adequate sites for the installations are present. The sediment elevation data will show how individual marsh sites are responding to sea level rise and will be useful in understanding what the proximate factors affecting marsh loss or gain are.

4.2.2 Additional Design Considerations

The decision of whether to use *permanent or temporary plots* will need to be addressed by each protocol. In general, the Network recognized that the use of permanent plots will reduce plot to plot variation and increase precision (Fancy 2000). However, the dynamic nature of coastal areas will frequently prohibit their use. In salt marsh vegetation and nekton monitoring, for example, the same marshes can be sampled on each visit, however, frequent changes in the amount of open water habitat will necessitate reselection of sampling sites within marshes every year. For salt marsh elevation monitoring the methods require permanently installed infrastructure.

To ensure that statistically interpretable data are collected *power analysis* of pilot data are required for determining adequate sample sizes for all protocols (Elzinga et al 2001). Power curves show the relationship between sample size, statistical power, and levels of detectable change. An understanding of this relationship will allow investigators to choose the minimum number of sampling units that will be necessary to detect protocol specific levels of change. Examples of this approach are shown in detail in the estuarine eutrophication, salt marsh vegetation, and salt marsh nekton protocols. See:

- Appendix 4.1, *Barrier Network Part I –Shoreline Position, Monitoring Protocols for the National Park Service North Atlantic Coastal*
- Appendix 4.2, Parks: Estuarine Nutrient Enrichment,

Whenever possible, *sample sites will be collocated* within and among projects to allow comparisons among components, decrease disturbance to natural areas, and maximize sampling effort (Fancy 2000). Since the most of the protocols to be implemented are ecosystem based there is only limited opportunities for collocation of sample sites. In a few cases sample sites can be used for multiple protocols.

For example, the Salt Marsh Nekton and Vegetation samples will be taken from the same marshes and, whenever possible, marsh elevation measurements will also be located in the same sites. From a park scale, several projects can be considered collocated. Salt marshes are located within sampled estuaries and the shorelines and adjacent habitats of both will be monitored by the geomorphic change and landscape change monitoring protocols.

The *temporal sampling frame* chosen for each vital sign depends on the scale of potential change, the monitoring objectives, and logistical concerns. Some vital signs, such as shoreline position and park usage will show both seasonal and annual trends and will therefore need to be measured at least twice a year. In contrast, changes in vital signs such as landscape pattern, soil organic content, and seagrass distribution may take several years to before they are detectable. As a result, these vital signs will me monitored every five to ten years. A summary of when and how often samples are taken for the vital signs are presented in table 4.1 and described in detail in the protocols.

4.3 Examples of Network Sampling Designs

The Network monitoring protocols are in varying stages of completion (see Chapter 5). At present, the estuarine eutrophication, salt marsh vegetation, and salt marsh nekton protocols are entering the review phase. Below are summaries of sample designs for these protocols. The shoreline change protocol is also nearing completion. Since complete surveys are used for this protocol the sample design will not be included here.

4.3.1 Sample design for the Estuarine Eutrophication Protocol

Monitoring responses to estuarine nutrient enrichment incorporates several spatial sampling designs to address questions at a hierarchy of scales (see Appendixes X-X). One vital sign, seagrass distribution, is measured completely within each park unit. Vital signs related to estuarine water quality and sediments are sampled using a probability design within entire park estuaries. For water quality vital signs, this spatial sampling is coupled with continuous monitoring at representative sites. The final vital sign, seagrass condition, is sampled using a probability design within selected seagrass beds. By combining small scale, coarse measurements of entire estuaries with large scale, high resolution measurements of selected areas, this mixture of sampling approaches and intensities enhances the likelihood of detecting changes in response to nutrient enrichment.

Measures of *seagrass distribution* include the size, location, and structure of beds of submerged aquatic vegetation (SAV) within each North Atlantic coastal park unit. Data are obtained by mapping all SAV beds within park boundaries from aerial photographs. Measurements are made by photo interpretation following national data standards for benthic habitat mapping (Finkbeiner et al. 2001). No spatial sampling design is implemented for this vital sign because the entire resource is mapped. SAV mapping occurs every five years.

Spatial sampling of *estuarine water chemistry, water quality, water clarity, and sediment organic carbon* uses a probability-based systematic survey design. The sampling framework for each park is a grid of tessellated hexagons that encompasses the estuarine area of interest. Grids contain 30 hexagons, and vital sign sampling occurs at a random location in each hexagon. The number of hexagons was determined based on the known spatial variability of vital sign measurements and the desired degree of change detection. The systematic survey of water-column measurements occurs weekly during a four-week summer index period each year, and the survey of sediment organic carbon occurs every five years. Because the survey is probability based, it allows inferences to be drawn regarding the status of entire park estuaries.

In addition to this spatial survey, one station is established at each park for continuous monitoring of water chemistry, water quality, and water clarity measures throughout each index period. These stations are not part of the probability design. Stations are selected to be representative of the overall estuary. Continuous monitoring data are not used to make inferences to other locations beyond the sampling stations. However, estuarine vital signs are known to exhibit a high degree of temporal variability, with important events occurring more frequently than weekly sampling may detect. Thus the continuous data are valuable in interpreting the patterns observed through systematic sampling.

Within-bed measures of *seagrass condition*, including percent cover, shoot density, canopy height, and areal biomass, are sampled using a cluster sampling design stratified by depth zone. One 50-m transect is randomly located within each of three depth zones (shallow, mid-depth, and deep) in an SAV bed that is representative of park SAV habitat. Twelve sampling locations are then randomly positioned along each transect. Sampling occurs within and adjacent to 0.25-m^2 plots, and plots are revisited at least annually; seasonal sampling (4 times per year) is advantageous if resources are available.

4.3.2 Sample design for the Salt Marsh Vegetation Protocol

The Salt Marsh Vegetation Protocol (see Appendixes X-X) describes methods used to sample salt marsh vegetation and associated cover types (*e.g*., water, bare ground, wrack or litter), as well as ancillary groundwater and soil salinity information. Salt marsh vegetation is sampled using $1m^2$ plots aligned along transects.

A stratified design is used to randomly select salt marsh sampling sites. For example, at Fire Island National Seashore, salt marshes were stratified by distance from an inlet and specific sampling sites were randomly chosen within each strata.

Selected marshes will be sampling every three years. Each year a the randomly selected study area is located then divided into sections (3-4 sections per area) and one transect is randomly located within each section. All transects are oriented perpendicular to the main elevation gradient of the marsh (*e.g*., from tidal creek to upland). If no elevation gradient is apparent or if there is no defined tidal creek, transects traverse the marsh from upland to upland.

The $1m^2$ vegetation plots are positioned along transects and the first plot is randomly located within the first 10 to 40m of the transect. All subsequent plots are located systematically located along the length of the transect at pre-determined intervals (*i.e*., 10m, 20m, 30m, *etc*.). The interval between adjacent plots is dependent on the length and the total number of transects per marsh.

The systematic division of the area with the random placement of transects and randomization of the first plot within each transect provides better interspersion of samples within the sample area. A minimum of 20 replicate, permanent, $1m^2$ vegetation plots, are sampled at each study site.

4.3.3 Sample design for the Salt Marsh Nekton Protocol

The Salt Marsh Nekton Protocol describes methods used to sample nekton (free-swimming fish and crustaceans) in shallow water (<1m) habitats such as salt marsh pools, tidal creeks, mosquito ditches, and shallow shoreline areas adjacent to salt marshes (see Appendixes X-X).

The same salt marshes chosen for study in the Salt Marsh Vegetation Protocol will be sampled for Nekton as well (i.e., protocols will be *collocated*). As above, A stratified design is used to randomly select salt marsh sampling sites.

Selected marshes will be sampling twice (once in the early summer and again in late summer) every three years. Within marshes nekton will be sampled in open water habitats (e.g., creeks, pools, and mosquito ditches) with throw traps and ditch nets.

Within each marsh, pools and larger tidal creeks (>1m wide) are sampled using the throw trap. If there are fewer than 15 pools on the marsh, then all pools are sampled. If there are more than 15 pools, then at least 15 pools are randomly chosen from the available pools. Typically, only one station per pool is desired, however, on larger pools two or three stations may be sampled as long as the stations are further than 30m apart. The specific station location on a pool from where throw trap is thrown is randomly located along the pool's perimeter. Locations of throw trap stations along shoreline areas and larger tidal creeks are randomly located along the length of the shoreline. Adjacent stations should be at least 30m apart. If closer placement of stations is necessary to achieve adequate replicate size, then adjacent stations must be sampled at least 30min to 1hr apart.

Ditch nets are used to sample grid ditches and smaller tidal creeks (<1m wide) of salt marshes. At least 10 ditch nets are sampled per marsh. Ditch nets are randomly located along the length of the ditch or tidal creek. Ditch nets should be at least 30m apart.

Chapter 5
Sampling Protocols

5.1 Introduction

The protocols for the five Network vital signs monitoring projects are summarized in Tables 5.1-5.6. These protocols will provide a mechanism to monitor the vital signs that have been selected by the Network to monitor the health of Network parks (see Chapters 1-3). Based on the timing of project development and the complexity of individual protocols, the status of protocol development varies among projects. The Ecosystem Indicators of Estuarine Eutrophication, Shoreline Position, Salt Marsh Nekton and Salt Marsh Vegetation protocols are completed and submitted for review along with this report:

- Appendix 5.1, *NCBN_GeomorphologicChange_PDS*
- Appendix 5.2, *NCBN_EstuarineEtrophicationNutrientInputs_PDS*
- Appendix 5.3, *NCBN_SaltMarshVegetation_PDS*
- Appendix 5.4, *NCBN_SaltMarshNekton_PDS*
- Appendix 5.5, *NCBN_EstuarineEtrophicationEcosystemIndicators_PDS*
- Appendix 5.6, *NCBN_SaltMarshSedimentElevation_PDS*
- Appendix 5.7, *NCBN_LandscapeChange_PD*
- Appendix 5.8, *NCBN_Park Use_ PDS*

The Network's additional 6 protocols are in development. Each of the protocols is summarized below. In addition, justifications for each vital sign and associated measurable indicators, descriptions of the monitoring approach for each protocol are located in the Protocol Development Summaries (Appendices XX-XX). See also Table 3.1 in Chapter 3 for a list of all vital signs and measures.

Monitoring of physical and/or biotic water resources, including wetland and shoreline resources, is a part of all five projects. Water quality monitoring makes up the bulk of the Estuarine Eutrophication project, and through the Ecosystem Indicators of Estuarine Eutrophication protocol several water quality indicators will be monitored. The Salt Marsh project will include three protocols that will monitor vegetation, nekton (fish and crustaceans), and marsh elevation in these critical coastal wetland habitats.

Marine hydrographic monitoring, including monitoring of bathymetry and the location and movement of shoals, will be a part of the Coastal Topography protocol in the Geomorphologic Change project, and thus will be used to assist with management of coastal resources and infrastructure. Wetland cover types will be monitored as part of the Landscape Change project. Finally, visitor use and impacts to marine, estuarine and coastal environments are part of the Visitor Use and Impacts project. The protocols for each of these projects do not separate water resources from other resources, but rather include all vital signs and indicators as part of integrated protocols.

Table 5.1 Vital Signs Monitoring Projects and Protocols

Project	Protocol	Protocol Development Summary Link	Park							
			ASIS	CACO	COLO	FIIS	GATE	GEWA	SAHI	THST
Geomorphologic Change	Shoreline Position	Insert Links	X	X		X	X			
	Coastal Topography	Insert Links	X	X	X	X	X	X	X	
Salt Marsh	Salt Marsh Nekton	Insert Links	X	X	X	X	X	X	X	
	Salt Marsh Vegetation	Insert Links	X	X	X	X	X	X	X	
	Salt Marsh Elevation	Insert Links	X	X	X	X	X			
Estuarine Eutrophication	Ecosystem Indicators of Eutrophication	Insert Links	X	X	X	X	X	X	X	
	Estuarine Nutrient Inputs	Insert Links	X	X	X	X	X			
Visitor Use and Impacts	Park Use as an Agent of Change	Insert Links	X	X	X	X	X	X	X	X
	Visitor Impacts to Park Resources	Insert Links	X	X	X	X	X	X	X	X
Landscape Change	Landscape Change	Insert Links	X	X	X	X	X	X	X	X

5.2 Geomorphologic Change

The problem of land loss/gain and landscape alteration at the marine edge is fundamental to the many issues facing coastal park resource stewards, and the two protocols in this project will generate a wide range of data on shoreline and coastal features, and will provide information that will improve understanding of the processes that drive coastal change at each park. Shoreline change is a prime indicator of coastal environmental resource threats within parks. Geomorphologic change is a basic concern because it not only impacts the shoreline resources but also drives change in other natural resources management areas such as water quality in ground and in estuaries, species and habitats of concern, recreational visitor use, and even resource extraction. Change in shoreline position drives the alteration and replacement of established natural habitats, and shoreline retreat may destroy cultural resources, facilities, and other infrastructure.

The primary geomorphologic variables operating in northeastern coastal parks are sea level rise, wave climate, and sediment supply. All eastern coastal parks are adversely affected by a relative rise in sea level (roughly 0.2-0.3 m in the last century). Although slow, this is a chronic driving force. Substantial shoreline retreat is also driven by aperiodic storms (tropical cyclones in summer and mid-latitude nor'easters in the winter). Storm effects upon the beach may be ameliorated within a week or two but if the system is degraded, a decade of storm quiescence may be needed for recovery. Furthermore, almost all-coastal locations have a declining sediment supply that contributes to coastal erosion. In addition to the primary variables, local conditions also control rates and direction of change. These include the geologic framework, offshore topography, orthogonal fetch limitations, and local sediment sources and sinks.

In addition to global, regional, and local natural causes, many cases of coastal erosion are accelerated by human perturbations to the natural system. Specific changes to tides, waves, currents, and availability of sediment have profound morphological and ecosystem feedback.

Examples range from stabilized inlets, seawalls, and groins, to hardened shorelines for inland protection, and beach and dune rebuilding with added sand from an external source. Habitat and ecosystem responses to such changes are not well understood by ecologists, and how long these impacts persist are virtually unknown at the local level.

Early identification of changes in past trends and an understanding of normal variability are the keys to recognizing ecological problems in coastal parks. The two protocols in this project will provide the historical and contemporary data sets that will provide this understanding (Table 5.3). A complete understanding these processes requires an adequate measurement of the hydrodynamic forcing of sediment transport, morphologic change, and ecosystem response at the level of the individual park unit. These are very complex tasks, which are beyond the capability of the National Park Service to perform alone. Acquiring some of the information in the Coastal Topography protocol will require concentrated cooperative effort between the NPS and other agencies. There are however, several measurable indicators and expressions of overall coastal process that can be monitored at the individual park level, including those detailed in both protocols. Some of these methods are well established and can be implemented quickly while others involving rapidly emerging technologies will require additional research and testing to develop.

Table 5.2 Summary of Geomorphologic Change Protocols

PROTOCOL 1: SHORELINE POSITION
Objective 1: Identification of the spatial and temporal variability in shoreline position
Question 1: *Is there a net displacement of the shoreline?* **Question 2:** *What are the seasonal dimensions of the displacement?* **Question 3:** *What are the storm related dimensions of the displacement?* **Question 4:** *Does the net displacement vary along shore?* **Question 5:** *Is there a spatial or temporal trend in the shoreline displacement?* **Vital Sign (Questions 1-5):** Shoreline Position
PROTOCOL 2: COASTAL TOPOGRAPHY
Objective 1: Identification of dimensional changes in the dune/beach topography.
Question 1: *Is there a net change in topography?* **Question 2:** *What are the seasonal dimensions of the topographic change?* **Question 3:** *What are the storm related dimensions of the topographic change?* **Question 4:** *Does topographic change vary along shore?* **Question 5:** *Is there a spatial or temporal trend in the topographic change?* **Vital Sign (Questions 1-5):** Coastal Topography
Objective 2: To understand the factors contributing to geomorphological change.
Question 1: *How does offshore topography (e.g., sediment quality, bathymetry, and location of migrating shoals and bodies) affect changes in the beach/dune system?* **Vital Sign:** Marine Geomorphology
Question 2: *How does the location of man-made structures and disturbances affect shoreline change?* **Vital Sign:** Anthropogenic Modifications

5.3 Salt Marsh Monitoring

Salt marsh ecosystems provide both important habitat and essential ecological services in NCBN parks. Salt marshes are among the most biologically productive ecosystems on earth, providing nursery grounds for recreational and commercial fishes among other species that are integral to the estuarine trophic food web, and providing habitat for endemic salt marsh plants as well as migratory shorebirds and water birds. In addition, salt marshes buffer coastlines from erosion and reduce nutrient inputs to estuarine and coastal ecosystems by filtering land-derived runoff. The three protocols for this project–Salt Marsh Nekton, Salt Marsh Vegetation, and Salt Marsh Elevation–will provide managers an opportunity to track changes to multiple resources simultaneously and therefore will also provide a mechanism for understanding the processes that may be affecting salt marshes in individual parks as well as the region.

Salt marsh communities are sensitive to disturbance and perturbations from natural causes such as storms and geomorphic processes, as well as human induced impacts associated with nutrient loading, watershed development, tidal restrictions and ditching. There is a long history of alteration of salt marshes along the Northeast coast including extensive ditching for mosquito control, salt hay farming, and restriction of tidal exchange by roads, causeways, bridges, and dikes. As the coastal corridor becomes urbanized watersheds become increasingly developed and salt marsh acreage declines and becomes fragmented. Urbanization leads to increased air pollution, intensified recreational use of coastal areas, and increases in septic and sewer systems and therefore in nutrient-laden runoff.

Developing and initiating long-term salt marsh monitoring in the Northeast Coastal and Barrier Network parks will help track natural and human-induced changes in salt marshes over time and advance our understanding of the interactions between salt marsh vegetation, nekton and the dynamic estuarine environment (Table 5.4). The elevation of a salt marsh reflects local, regional and global processes, for example sea level rise, or the abundance, availability and movement of sediments. Vegetation patterns in salt marshes are indicative of changes to hydrology such as would be caused by sea level change or alteration of tidal regime by natural (e.g. inlet formation or closing) or anthropogenic (e.g. diking, restoration) causes. Invasive plant species such as the common reed (*Phragmites australis*) can dominate lower salinity salt marsh areas such as areas with restricted tidal flow. Nekton, defined here as free swimming fishes and crustaceans, is an abundant estuarine fauna that provides an integral link between primary producers, consumers, and top predators and is likely to respond to either top-down or bottom-up estuarine perturbations. For example, nutrient enrichment (a bottom–up perturbation) could affect nekton by altering submersed vegetative habitats that serve as nursery grounds. Conversely, removal of predatory fishes through overfishing (top-down) could induce responses in the forage or prey nekton. Nekton also represent a significant portion of the diets of many fish-eating birds, economically valuable fishes, and, when in estuaries, marine mammals.

Table 5.3 Summary of Salt Marsh Protocols

PROTOCOL 1: SALT MARSH NEKTON
Objective 1: To understand long term changes in salt marsh vegetation and nekton communities
Question 1: *Is nekton community structure (species composition, abundance, and size structure) changing over time (e.g., decades)?* **Vital Sign:** Salt Marsh Nekton Community Structure

Objective 2: To understand responses of salt marsh vegetation and nekton communities to environmental change.

Question 1: *How do salt marsh communities change in response to perturbations (e.g. invasive species, oil spills, storms) in the environment?*
Vital Sign: Salt Marsh Nekton Community Structure

PROTOCOL 2: SALT MARSH VEGETATION

Objective 1: To understand long term changes in salt marsh vegetation and nekton communities

Question 1: *Are salt marsh vegetation patterns (species composition and abundance) changing over time (e.g., decades)?*
Vital Sign: Salt Marsh Vegetation Community Structure

Objective 2: To understand responses of salt marsh vegetation and nekton communities to environmental change.

Question 1: *How do salt marsh communities change in response to perturbations (e.g. invasive species, oil spills, storms) in the environment?*
Vital Sign: Salt Marsh Vegetation Community Structure

PROTOCOL 3: SALT MARSH ELEVATION

Objective 1: To understand how salt marsh elevations respond to local sea-level rise

Question 1: *Are salt marsh surface elevation trajectories changing over time (e.g., decades), and if so, what factors are contributing to observed elevation changes (e.g., surface versus subsurface processes, changes in organic matter accumulation)?*
Vital Sign: Salt Marsh Sediment Elevation

Question 2: *Are salt marsh surface elevation trajectories keeping pace with the local rate of sea-level rise?*
Vital Sign: Salt Marsh Sediment Elevation

5.4 Estuarine Eutrophication

Approximately one quarter of the NPS land area within the Coastal and Barrier Network is submerged. These estuaries, bays, and lagoons serve as islands of relatively pristine aquatic habitat within the Northeastern urban corridor. The North Atlantic coastal parks are dependent on high-quality aquatic resources to sustain the complex estuarine and near-shore ecosystems they represent. Diverse threats to NPS estuaries exist, including natural disturbances (e.g. storms, sea-level rise), direct impacts of human activities (e.g. fishing, boating, dock construction), indirect effects of watershed development, and disasters. Of these, park managers throughout the Network have repeatedly identified threats to coastal water quality as one of their highest priority management issues. Much of the watershed area of NPS coastal ecosystems lies outside protective park boundaries and is subject to intense developmental pressures. Therefore, there is great potential for human disturbances to coastal watersheds to result in increased nutrient loading to park estuaries.

Estuaries can generally assimilate some degree of enrichment without major ecological ramifications, but excessive nutrient inputs typically lead to dense blooms of phytoplankton and fast-growing macroalgae, loss of seagrasses, and decreased oxygen availability in sediments and bottom waters. Ultimately, cascading effects include changes in the species composition and abundance of invertebrates, decline in fish and wildlife habitat value, and the collapse of fin-and shellfish stocks. Protecting the ecological integrity of park estuaries depends on implementing a scientifically-based monitoring program that is capable of diagnosing local causes of nutrient enrichment, detecting changes in nutrient loads, and determining if nutrient inputs are near to exceeding thresholds that would result in shifts in ecosystem structure and function (Table 5.2). The two protocols in this project will provide two types of information that will help park management track and predict estuarine eutrophication. The Ecosystem Indicators of Estuarine Nutrient Enrichment protocol will directly measure several water quality indicators, and the Estuarine Nutrient Inputs protocol will provide watershed-level estimates of nutrient inputs from a range of sources every five years.

Table 5.4 Summary of Estuarine Eutrophication Protocols

PROTOCOL 1: ECOSYSTEM INDICATORS OF ESTUARINE EUTROPHICATION	
Objective 1: Determine if nutrient loads to Park estuaries are increasing.	
	Question 1: *Based on a four-week summertime index period, are there detectable inter-annual trends in the following estuarine water chemistry constituents: dissolved oxygen concentration, turbidity, attenuation of photosynthetically active radiation, temperature, and salinity?* **Vital Sign 1:** Estuarine Water Chemistry **Vital Sign 2:** Estuarine Water Clarity
	Question 2: *Based on a four-week summertime index period, are there detectable inter-annual trends in estuarine suspended chlorophyll concentrations?* **Vital Sign:** Estuarine Water Quality
	Question 3: *Are there detectable inter-annual trends in the level of organic carbon in estuarine sediments?* **Vital Sign:** Estuarine Sediment Organic Carbon
Objective 2: Determine if estuarine resources are changing in response to nutrient inputs.	
	Question 1: *Is the distribution and abundance of submerged aquatic vegetation beds changing?* **Vital Sign:** Seagrass Distribution
	Question 2: *Are there detectable inter-annual trends in the following within seagrass-bed measures of seagrass condition: shoot density, percent cover, and aerial biomass?* **Vital Sign:** Seagrass Condition
PROTOCOL 2: ESTUARINE NUTRIENT INPUTS	
Objective 1:Determine if nutrient loads to Park estuaries are increasing	
	Question 1: *Can the following land-use proxies for nutrient loads: human population density, non-point source discharge permits, permitted water withdrawals for domestic and agricultural consumption, fertilizer consumption, livestock populations be used to estimate nutrient inputs into Park estuaries?* **Vital Sign:** Estuarine Nutrient Inputs

5.5 Visitor Use and Impacts

The parks of the Northeast Coastal and Barrier Network are located in a heavily populated region, and park resources are potentially impacted by large numbers of visitors and in-park and near-park residents, as well as in-park and near-park resource consumption activities such as fin and shell fishing. The Network Technical Steering Committee identified park user impacts as one of five key management issues, and this has been supported by park staff throughout project development.

Recreational and other park use levels and impacts are a concern in all park habitats, from upland forests and fields to eroding coastal bluffs, estuarine marshes, and near shore open water habitats. Park uses include hiking, dog walking, and bicycle riding on official and social trails, off road vehicle driving on beaches and backcountry areas, fin and shell fishing, boating with motorboats, canoes and kayaks in estuarine and marine areas, and park based maintenance, interpretation, and resource management activities.

In order to assist park managers in determining how best to protect resources and manage for a variety of park uses, two monitoring protocols will be developed (Table 5.5). One protocol will identify types and locations of park uses and estimate the amount of each type of use. The second protocol will address impacts associated with park uses, such as wildlife disturbance events and the formation of social trails.

Table 5.5 Summary of Visitor Use and Impacts Protocols

PROTOCOL 1: PARK USE AS AN AGENT OF CHANGE

Objective 1: Understand the Character of Park Use as an Agent of Change in CBN Parks.

Question 1: *What types of official park use activity currently exist?*
Question 2: *What types of unofficial and illegal park use activity currently exist?*
Question 3: *What is the amount of park use for each official type?*
Question 4: *What is the amount of park use for those unofficial/illegal types that have been documented?*
Question 5: *What is the spatial distribution of current visitor use?*
Question 6: *What is the temporal distribution of current visitor use?*
Question 7: *What are the trends of visitor use over the past decade or more?*
Vital Sign: (Questions 1-7): Park Usage

PROTOCOL 2: VISITOR IMPACTS TO PARK RESOURCES

Objective 1: Understand the Types, Patterns and Trends of Habitat Degradation Associated With Unofficial Trails and Recreation Sites

Question 1: *What types of habitat degradation exist?*
Question 2: *What is the extent and distribution of social trails?*
Question 3: *What is the extent and distribution of unofficial recreation sites?*
Question 4: *What are the spatial and temporal trends of social trails and unofficial recreation sites?*
Question 5: *What is the spatial relationship between social trails and unofficial recreation sites and known habitats of RTE species?*
Question 6: *To what extent are the patterns of social trails and unofficial recreational use associated with the patterns of park use?*
Question 7: *What are the other types of habitat degradation that are attributable to park use activities (e.g., illegal collection, tree damage)?*
Vital Sign: (Questions 1-7): Habitat Alteration

Objective 2: Understand the Patterns and Trends of Direct Ground Disturbance to Terrestrial and Benthic Habitats by Park Use

Question 1: *What is the extent of ground disturbance within terrestrial habitats?*
Question 2: *What is the extent of ground disturbance within benthic habitats?*
Question 3: *What is the distribution of ground disturbance within terrestrial habitats?*
Question 4: *What is the distribution of ground disturbance within benthic habitats?*
Vital Sign: (Questions 1-5): Habitat Alteration

Objective 3: Understand the Types, Patterns and Trends of Wildlife Disturbance Associated With Park Use

Question 1: *What types of use-related wildlife disturbance exist?*

	Question 2: *Specificially, what types of wildlife attraction behavior exist?* **Question 3:** *Where and when does each type of wildlife disturbance occur most often?* **Question 4:** *What is the spatial and temporal distribution of wildlife attraction behavior?* **Question 5:** *To what extent is the distribution of wildlife attraction behavior related to the distribution of park use?* **Question 6:** *What are the spatial and temporal trends of wildlife disturbance, including wildlife attraction behavior?* **Vital Sign: (Questions 1-6):** Wildlife Disturbance

5.6 Landscape Change

The primary goal of this protocol will be to monitor land cover change in both terrestrial and sub-tidal environments within all of the Northeast Coastal and Barrier Network (NCBN) parks. All NCBN parks have identified monitoring of land cover change as an important and necessary tool for future management practices. The Network's science committee also identified terrestrial and aquatic vegetation monitoring as a priority issue to be addressed by the NCBN inventory and monitoring program. Land-cover change monitoring will help to establish a landscape context for each park, giving natural resource managers a better understanding of how park ecosystems fit into the broader landscape, and will assist them to prioritize ecosystem management. An assessment of land-cover changes will provide estimates of habitat changes within and around parks that can identify priority ecosystems to monitor within the park. The quantification of land-cover changes over time can be used to examine relationships between land-cover change and wetland plant communities (Lopez et al., 2002), water quality, and general ecosystem health (Paruelo et al., 2001). By developing and implementing a protocol to efficiently and cost effectively monitor land cover change within NCBN parks, the current knowledge of park ecosystem dynamics will be further advanced, allowing for better management practices and decision making in the future. The expectation is that the landscape elements of each Network park will be monitored and the trends analyzed every five to ten years.

Table 5.6 Summary and Landscape Change Protocol

PROTOCOL 1: LANDSCAPE CHANGE	
Objective 1: Quantify landscape change in and around Northeast Coastal and Barrier Network Parks.	
	Question 1: *How are the dominant habitat cover types changing over time (both terrestrial and subtidal aquatic habitats)?* **Vital Sign:** Landscape Pattern
	Question 2: *How are landscape pattern metrics (e.g., indices of habitat: patch size, patch density, fragmentation, and isolation) changing over time?* **Vital Sign:** Landscape Pattern

Chapter 6
Data Management

As the basic and most important products of scientific research, data and information represent a valuable, and often, irreplaceable resource (Michener and Brunt, 2000). Because field experiments and associated data collection are often time consuming and expensive, management of data and information products plays an important role in any scientific program. For long-term ecological monitoring programs, such as the NCBN Inventory and Monitoring Program, retention and documentation of high quality data are the foundation upon which the success of the overall program rests.

In order to develop and retain high quality data, the network has developed a draft information management plan (Appendix 6.1) that describes the Network's information management infrastructure (e.g., staffing, hardware, software) and architecture (databases, procedures, archives). This includes procedures to ensure that relevant natural resource data collected by NPS staff, cooperators, researchers, and others are entered, quality-checked, analyzed, reported, archived, documented, cataloged, and made available to others for management decision-making, research, and education.

In addition to the Network's Information Management Plan, NCBN staff are developing specification and guidance documents to share with park, network, regional and national staff (http://www1.nature.nps.gov/im/units/ncbn/d_guidelines.htm). These guidelines describe methods that will be used by NCBN for managing natural resource information from hard copy reports to digital photos. Standard Operating Procedures (SOP) that describe in detail how to create FGDC compliant metadata or conduct quality control procedures on data collected by the network are also being developed and included each of the Network monitoring protocols.

In order for the NCBN Information Management Plan to be successful, the Network must:

- provide up-to-date technical guidance for the preparation and management of data (guidance, specification and Standard operating procedure documents); and
- maintain efficient standards for data processing, from acquisition to distribution.

Success will be based on the resulting:

- production and maintenance of high quality information products that fulfill a wide variety of user needs

The NCBN Information Management plan outlines the approach that the Northeast Coastal and Barrier Network will take to implement and maintain a system that will serve the data and information management needs of the NCBN Inventory and Monitoring Program. The plan reflects the commitment to the establishment, maintenance, description, accessibility, and long-term availability of high-quality data and information.

6.1 Roles and Responsibilities

For the NCBN Inventory and Monitoring program to work effectively, everyone within the Network will have stewardship responsibilities in the production, analysis, management, and/or end use of data produced by the program. In order to meet the new data management goals and standards developed by the National Park Service and its constituents, Network staff must understand how data and information flow, and what their roles and responsibilities are in this process.

There are four main categories of data stewardship roles to be handled by Network personnel. These are:

1. production;
2. analysis;
3. management; and
4. end use;

Each of these broad categories has principal, or 'must-do' responsibilities as well as many potential ancillary tasks. As coordinator of these tasks, the fundamental role of the Network data manager is to understand and determine program and project requirements, to create and maintain data management infrastructure and standards, and to communicate and work with all responsible individuals.

6.2 NCBN Project Workflow

To better understand the information management needs of the NCBN program, it is useful to understand the general work flow of project development, and the information management tasks associated with each stage. There are two main types of projects handled by the Network:

- Short-term projects, which may include individual park research projects, inventories, or pilot work done in preparation for long-term monitoring; and

- Long-term projects, mainly the network vital-signs monitoring projects central to the I&M program, but which may also include multi-year research projects and monitoring performed by other agencies and cooperators. Long-term projects will often require a higher level of documentation, peer review and program support.

For information management the primary difference between short- and long-term projects is an increased need to adhere to and maintain standards for long-term projects. Maintaining standardization from year-to-year is necessary when comparing data over an extended period of time (years for vital signs monitoring).

Within this information management plan, projects, both short and long-term, are divided into four primary stages:

1. initiation and approval;
2. planning-design and testing;
3. implementation;
4. finalization-product integration and evaluation.

Each of these four stages are associated with multiple information management tasks. During the *initiation and approval stage*, preliminary decisions are made regarding the scope of the project and its objectives. A scope of work may or may not be written for each project, but a proposal is developed and funding sources, permits and compliance addressed. A cooperative agreement or contract is developed and finalized. Although many of these responsibilities rest with the project leader and/or program administrators, data management staff must be involved in identifying project deliverables and assuring that each contract or agreement includes a clear list of these deliverables, with reference to either national, regional or network information and data standards.

At the *planning-design and testing stage* of a project either an inventory study plan or monitoring protocol is developed that details how data will be acquired, processed, analyzed, and reported. Information management tasks associated with this stage include data design, development and maintenance of guidelines and specifications, and dissemination of this information. This stage is one of the most important as it initiates the development of sound, quality data products.

Once the design and testing, and the administrative tasks associated with project information management have been completed, the project *is implemented.* At this stage the technical information management staff is critical to the success of the project. Tasks include acquiring, processing, and documenting data. During this phase, products such as reports, maps, and GIS themes, are developed. All raw data undergo QA/QC measures and final manipulated products are reviewed. Although many of these tasks may be completed by Network cooperators, the information management staff must be closely involved in the training, development and review of all draft and final project products.

Once all products have been developed and gone through extensive review, *product integration and evaluation* takes place. Records are either finalized permanently for short-term projects, or finalized for the project year for long-term projects. Records are finalized or closed out for the year in the network project tracking database to reflect status and deliverables. Information management tasks include the review, dissemination and archiving of all products.

Although all Network projects vary in terms of the final products they produce, all follow these four basic stages. The differences between projects occur within the stage itself and are dependent on the category and type of data being collected or compiled. This dictates how data are acquired and processed within each project stage.

6.3 Data Acquisition and Processing

There are two categories of data acquired and managed by the Network:

1. **Network-based data**-those data collected by Network staff and/or cooperators working with the Network; and

2. **Network-integrated data**-those data collected by other entities (parks, universities, other agencies, other NPS programs), but identified as important natural resource data, necessary for the Network to manage.

Network-based data are those data originating within the Network or are currently being collected by NCBN staff. These include three of the twelve basic I&M Program biological inventory datasets:

1. vegetation maps;
2. species occurrence inventories; and
3. species distribution inventories.

Along with vegetation maps and species inventories, the Network manages long-term monitoring data as part of its Vital Signs program. NCBN is currently developing protocols to monitor:

1. salt marsh vegetation;
2. estuarine nekton;
3. geomorphologic change;
4. estuarine nutrient enrichment;
5. landscape change; and
6. visitor impacts.

Network-Integrated data can be divided into two more data type categories:

1. *Current or ongoing datasets*-These datasets are pre-determined for acquisition by the network and follow very specific acquisition and processing steps. These can either be park-based or from external NPS sources. They are protocol dependent datasets that the network acquires on a regular basis. These datasets are either used for data analyses and comparison purposes with network-based monitoring data, or they are baseline datasets essential for the completion of a vital sign monitoring protocol.

2. *Legacy datasets*-are those data found and compiled through the data mining process. These include vertebrate and vascular plant species data, other important natural resource inventory data, specimen or voucher data, bibliographic data, and existing monitoring datasets.

Network-based data and Network-integrated data follow slightly different acquisition and processing steps. These are described in detail in the NCBN Information Management Plan (Appendix 6.1, Chapter 5). Field data (Network-based data), data acquired from external sources and legacy data (Network-integrated data), are handled through a variety of steps to reach their final archiving stage. Although some of the steps differ from one data type to another such as the acquisition and dissemination steps, there are four main steps that all NCBN data undergo once acquired:

1. quality assurance/quality control;
2. documentation;
3. transcription to master databases; and
4. archiving.

Data and information are stored, maintained and disseminated through network and nationally based database management systems. Details are available in the Network plan (Appendix 6.1 Chapter 5). NCBN vital signs data are stored in the NCBN monitoring database template. Network water quality data are housed in the national water quality database STORET. Species data are managed in the NPS NPSpecies database, and bibliographic data compiled by the Network in the NPS NatureBib database.

6.4 Quality Assurance, Quality Control

When developing a long term ecological monitoring program, it is imperative that information and data developed as part of the program be of high quality and adequate for its intended use (US EPA, 2001). In order to develop quality products, a plan for quality assurance as well as methods for quality control must be developed at all levels of the program. Network staff and cooperators conducting ecological monitoring must be aware of both the need for and the mechanisms to achieve excellence at all levels of product development. In order to accomplish this, NCBN is developing a quality management system. The Network's quality management system will include the organizational structure, responsibilities, procedures, processes and resources for implementing QA/QC for its ecological monitoring program.

NCBN will establish guidelines for the identification and reduction of error at all stages in the data lifecycle, including project planning, data collection, data entry, verification and validation, processing, and archiving. This approach requires that the network will:

- develop a plan for quality assurance that will include the identification of roles and responsibilities of network, park and cooperative staff for maintaining quality standards at all levels of the program, from field and laboratory data collection to overall data management procedures;
- ensure that the process of achieving quality is not only documented, but maintained through routine review by network staff;
- develop protocols and SOPs to ensure data quality;
- evaluate the quality of all data and information based on NPS standards before data are distributed; and
- perform periodic data audits and quality control checks to monitor and improve the network's data quality program.

Much QA/QC work involves defining and enforcing standards for electronic formats, locally defined codes, measurement units, and metadata. This process begins with data design and continues through acquisition, entry, metadata development, and archiving. The progression from raw data to verified data to validated data implies increasing confidence in the quality of the data through time. Documentation of the dataset's quality review process are added to the project metadata.

6.5 Data Documentation

Another critical step following quality assurance and control is data documentation. Data documentation is another step towards ensuring that datasets are useable for their intended purposes well into the future. This involves the creation of metadata. Metadata describes how, when and by whom a particular set of data was collected, and how the data are formatted. It also includes information about the quality, condition, and characteristics of a dataset. Metadata help to create and maintain a framework for cataloging datasets, to help make them more readily available to a broad range of users.

A significant amount of guidance has become available on proper data documentation (See NCBN Information Plan Appendices). As mandated by the National Park Service, all NCBN metadata associated with geospatial data will conform to Federal Geographic Data Committee (FGDC) standards. There are a variety of software tools available for creating and maintaining FGDC compliant metadata.

For biological datasets, NCBN has adopted the Biological Data Profile Metadata standards developed by the National Biological Information Infrastructure (NBII). All network-based datasets will be accompanied by the Biological Data Profile when distributed. Northeast Region cooperators have developed helpful guidelines on tools used for creating Biological Data Profile metadata (see Plan Appendices).

NCBN data management staff will provide training and support to project leaders to facilitate metadata development. Upon completion, metadata will be posted so that it is available and searchable in conjunction with related data and reports via the NCBN website, as well as the national NR-GIS Data Store.

6.6 Data Distribution

Access to NCBN data products will be facilitated via a variety of information systems that allow users to browse, search and acquire network data and supporting documents. These systems include the NCBN website, and national applications with internet interfaces (NatureBib, NPSpecies, NR-GIS Data Store, etc.). The following table provides a list of repositories and types of data that will or can be housed there (Table 6.1).

Table 6.1. Information management systems that facilitate dissemination of NCBN information.

Web Application	Data types available at site	Web Address
NPSpecies	Data on park biodiversity (species information)	http://science.nature.nps.gov/im/apps/npspp/index.htm
NatureBib	Scientific citations related to park resources	http://www.nature.nps.gov/nrbib/index.htm
NR-GIS Metadata and Data Store	Metadata, spatial and non-spatial data products	http://science.nature.nps.gov/nrdata
Biodiversity Data Store	The raw or manipulated data and products associated with I&M data that have been entered into NPSpecies.	http://science.nature.nps.gov/im/inventory/biology/index.htm
NCBN Website	Reports and metadata for all network projects	http://www1.nature.nps.gov/im/units/ncbn/index.htm

Because network data will reside in the repositories listed above, this data will automatically be searchable via the integrated metadata and image management system and search gateway called NPS Focus. This system is being built with Blue Angel Enterprise software for metadata management and the LizardTech Express Server for image management. Currently ten NPS and two non-NPS databases have been integrated into the NPS Focus prototype in either full or test bed form for one stop searching. NPS Focus has been released as an Intranet version only (http://focus.nps.gov/) – release of a public version is projected in the near future.

6.7 Archiving

The final information management step, and one of the most vital to the Network's Inventory and Monitoring Program, is the long-term maintenance and management of digital and analog information. Technological obsolescence is a significant cause of information loss, and data can quickly become inaccessible to users if they are stored in out-of-date software programs or on outmoded media. Effective maintenance of digital files depends on the proper management of a continuously changing infrastructure of hardware, software, file formats, and storage media. Major changes in hardware can be expected to occur every 1-2 years and in software every 1-5 years (Vogt-O'Connor 2000).

As software and hardware evolve, datasets must be consistently migrated to new platforms, or they must be saved in formats that are independent of specific platforms or software (e.g., ASCII delimited files). Thus, NCBN archiving procedures include saving datasets in both their native format (typically MS-Access or Excel spreadsheet format) and as sets of ASCII text files. As a platform- and software-independent format, ASCII text files ensure future usability of the data in a wide range of applications and platforms. In addition, datasets will periodically be converted to upgraded versions of their native formats.

Chapter 10 of the NCBN Information Management Plan describes procedures for maintaining and managing digital data, documents, and objects that result from Network projects and activities. These procedures will help ensure the continued availability of crucial project information and permit a broad range of users to obtain, share, and properly interpret that information.

Chapter 7
Data Analysis and Reporting

7.1 Introduction

Each vital sign monitoring project is designed to assess long term trends (sometimes along with short term changes) that will address issues of management concern. Therefore it is essential that data collection, analysis, and reporting are each designed at the outset to accommodate this long term approach and to ensure that the information from each project is shared with park managers and the public. Standard reporting formats and procedures will ensure regular reporting on each project, that each project will be implemented and results reported following the same procedures regardless of changes in Network, park, or cooperating staff, and that each report will be easily identified with its project, the Network, and the parks in which it is implemented. This chapter summarizes the reports that will be produced by the Network. Specific data collection and analysis methods are detailed in each protocol, and will not be covered in this chapter

Determining reporting formats and schedules along with data analysis procedures before project initiation will greatly reduce the difficulties that can be faced in monitoring projects. For example many projects are stalled or changed drastically by unexpected circumstances in the field when field sampling is conducted prior to determination of the content of analyses and reports, or when monitoring begins without pilot sampling. The thorough planning being done for vital signs monitoring results in an overall slower planning process, however. Also, even the most thorough planning may not account for significant future changes to the resources being sampled, or challenges with the logistics of implementing the project. The protocol for each project accommodates this by including a standard operating procedure (or SOP) that defines a process for making changes to the existing protocol. Any changes to protocols will be considered for their impact on analyses, and the changes and justifications will be reflected in subsequent reports.

7.2 Summary of Expected Northeast Coastal and Barrier Network Reports

Reports are the primary means of communicating the work of the Network and the results of each vital signs monitoring project. Following the completion of this Monitoring Plan and the initiation of monitoring projects, the reports will serve as the focal point of the NCBN monitoring program for parks and the public. It is therefore essential that all reports serve specific purposes that are meaningful to parks and the public, are clearly written, consistently formatted, easily identified with the Network and Network parks, and are targeted to intended audiences.

The Network Coordinator has the ultimate responsibility for ensuring that all reports are completed on time and according to the specifications detailed in this chapter. Each protocol is being developed by cooperating scientists under the terms of signed agreements that require they complete the protocol according to the specifications of the Inventory and Monitoring Program and submit them to the Network Coordinator. The projects are being implemented at least initially by these cooperators in partnership with Network and park staff, and project reports will similarly be submitted to the Network Coordinator. The personnel structure for any of the projects may change over time, shifting the responsibility for completing draft reports to Network or park staff, or other cooperating individuals or groups. In this situation, the contract, agreement, or work plan of the newly responsible individual will clearly state the requirement to follow all specifications of the Inventory and Monitoring Program, and those that are detailed in this Plan and any subsequent amendments, and to submit draft and final reports to the Network Coordinator.

Five types of reports will be produced on a regular basis by the NCBN vital signs monitoring program: (1) Annual Executive Summary of Network Project Highlights (Network Highlights) (2) Annual Administrative Report and Work Plan, (3) Annual Project Reports, (4) Project Trend Reports, and (5) Program and Protocol Review Reports. The content of each of these reports and the frequency and schedules for Project Trend Reports and Program and Protocol Review Reports is described below.

7.2.1 Network Highlights

An annual list and description of noteworthy accomplishments and findings from all Network projects, in a one to two page executive summary style, will be completed and distributed by September 15th. This will include both inventory and monitoring work, as well as related research and management, from all projects affiliated with the Network Inventory and Monitoring Program. Examples include a summary table of projects being implemented in each park, significant trends in particular park resources, examples of management decisions that have been made using vital signs monitoring information, or any newly discovered species, or populations of rare species. This is intended to serve as an easy reference for park superintendents and other senior park staff, as well as national, regional, and park public affairs offices. It will also be submitted to national and regional Inventory and Monitoring offices for consideration of inclusion of items in the annual NPS State of the Parks Report.

7.2.2 Annual Administrative Report and Work Plan

This report is divided into two parts that will be completed separately and combined in a final report. The annual administrative report for the Network will be completed and distributed by October 31st of each year. The annual work plan will reflect the results of previous year's projects, as well as comments on the administrative report, and the final combined report will be completed by January 31st. This report serves as a progress report for the previous year and a work plan for the following year, and is intended for the Network Board of Directors, the National and Northeast Regional I&M staff, and any interested park personnel. The report will include the following information:

- Review of Network operations, personnel and budget, including accomplishments.
- Status of and communications with the Network Board of Directors and Technical Advisory Committee.
- Summary of the status of each project, including accomplishments and products.
- Detailed summaries of any amendments to the NCBN Vital Signs Monitoring Plan (e.g. additional project protocols added, changes to existing protocols).
- Detailed work plan for the following year with specific objectives and tasks.

7.2.3 Annual Project Reports

Reports for each of the major NCBN vital signs monitoring projects will be completed every year by December 15th. These reports will include results from a standard, limited set of analyses, primarily providing simple summary statistics of the vital sign indicators in order to allow a quick assessment of the status of resources. More information on what will be reported through each protocol is found in the SOP for Data Analysis of each protocol. Intended for park resource managers, NCBN staff and external scientists and interested public, each of these reports will include the following:

- A descriptive summary of monitoring activities for the previous year and significant findings.
- Results and discussion of analyses that are completed annually (additional analyses will be conducted for the Project Trend Reports, as described below).
- Summary of the condition of the resources represented by the selected vital signs.
- Detailed information on the location and management of all monitoring data for the project.
- Discussion of any current problems that may impede performance and proposed corrective actions.

7.2.4 Project Trend Reports

Comprehensive trend reports from the five vital signs monitoring projects, along with the Program and Protocol Review Report, will be produced one per year to make up a six year rotating schedule (Table 7.1). By sequencing the reports in this way, the Network will be able to provide a substantial report to parks each year, and Network staff and cooperators will be able to dedicate appropriate time to each report. The ordering of project trend reporting depends on when the project was initiated, the vital signs being monitored, and the status of the protocols for each project.

For example, due to the large amount of historic and pilot sampling data and the completion of the draft Shoreline Position protocol, the first trend report will be from the Geomorpholgic Change project in 2006, followed by the Salt Marsh project in 2007 and so on (Table 7.1). Trend reports will include a full complement of analyses in order to synthesize the data collected into meaningful patterns at the park, local, and regional levels. These reports will also compare observed values with pre-determined threshold values that serve as triggers for management action or supplemental research. The intended audience for trend reports includes National, regional and Network Inventory and Monitoring Program staff, park management and field staff, the scientific community, and the public. The following elements will be included in these reports:

- Summary of the condition of the resources represented by the selected vital signs.
- Analysis of the data to assess the spatial and temporal variation of each vital sign indicator. This will supplement the work done in project planning and pilot sampling by providing further information on the amount of change that can be detected by each sampling method.

- Quantitative summary and discussion of patterns and trends in the condition of resources being monitored, including any new characteristics of resources, correlations among resources being monitored, and comparisons of observed values with pre-determined threshold values that should trigger management actions or supplemental research.
- Interpretation of the data at the park level, and where appropriate at the regional or national levels. Analyses and interpretation will be discussed in a regional and national context.
- Discussion of recommend changes to resource management for any pertinent Network parks (*i.e.*, feedback for adaptive management).
- Detailed information on the location and management of all monitoring data for the project.

7.2.5 Program and Protocol Review Reports

As part of the quality assurance process for the Inventory and Monitoring Program, program review reports will assess the quality and efficiency of Network operations, including a review of protocol designs, products and reports for each of the vital signs monitoring projects. The NCBN Program and Protocol Review Report will be produced every 6 years as part of a rotating schedule along with the five vital sign monitoring project trend reports (see Table 7.1). This report will be produced after each full cycle of trend reports in order to allow for a better assessment of the status of the Network and each project.

7.3 Project Report Schedule

Table 7.1 Network Vital Signs Project Trend Report and Protocol Review Schedule
Note – Each project will also produce Annual Project Reports.

Project	Protocol	Year and Report T = Trend Report R = Program and Protocol Review											
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Geomorphologic Change	Shoreline Position Coastal Topography		T					R	T				
Salt Marsh	Salt Marsh Nekton Salt Marsh Vegetation Salt Marsh Elevation			T				R		T			
Estuarine Eutrophication	Ecosystem Indicators of Eutrophication Estuarine Nutrient Inputs				T			R			T		
Visitor Use and Impacts	Park Use as an Agent of Change Visitor Impacts to Park Resources					T		R				T	
Landscape Change	Landscape Change						T	R					T

7.4 Submission and Formatting Guidelines for Reports

7.4.1 Submission Guidelines

The person responsible for completing a project Annual Report or Comprehensive Project Report must submit a draft final report to the NCBN Network Coordinator. Review comments and recommended changes will then be returned to the author(s) for consideration and preparation of the final report. All appropriate comments from draft final report reviews should be addressed and incorporated into the final report. Before duplication, a copy of the final report must be sent to the Network Coordinator for final approval of review modifications and format. Upon approval, a letter quality original, reproducible copy of the final report must be submitted on or before the date identified in the research permit, contract, or agreement. A CD, containing the report in MS Word must be submitted along with the paper copy.

7.4.2 Formatting Guidelines

All reports submitted to or completed by the NCBN will follow detailed formatting guidelines, located in the Draft Northeast Region Natural and Science Study Proposal and Deliverable Guidelines. These guidelines have been created for all Technical Reports in the NPS Northeast Region, including scientific reports that are generated from the Inventory and Monitoring Program such as the project trend reports.

7.5 Data Analysis and Management Responsibilities

Each vital signs monitoring protocol will include standard operating procedures for analyses that will be performed both for the annual reports and the trend reports. The annual report analyses mostly consist of the generation of summary statistics for a given year's work. For example, the number of species sampled and the estimated percent cover for each species in the Salt Marsh Vegetation protocol, or the average Photosynthetically Active Radiation (PAR) for a given sample station in the Ecosystem Indicators of Estuarine Eutrophication protocol. Microsoft Access databases will be utilized for each protocol to generate these summary statistics. Further details about the database design, and examples, are found in the Data Management Plan (see Appendix 6.1, *NCBN_Information Management Plan*).

The analyses for trend reports require substantially more oversight for their planning and implementation, as these reports will provide the most important information regarding the status of vital signs and thus the health of park ecosystems. The Network Coordinator is ultimately responsible for these analyses and their reporting, however the responsibility for the multiple steps involved in taking the data collected in the field through to the analysis and reporting stages is distributed among several program and project staff. The Network Data Manager provides overall planning, training, and operational support for the coordination and integration of data and information management activities, and is responsible for the design and maintenance of the databases. The Project Leader for a given vital signs project is responsible for ensuring that field data collection is properly done, conducting the trend analyses, and developing the trend report. The Project Leaders for the initial implementation of protocols may be university cooperators, however these roles will be shifted to Network staff (from the Science Staff described in Chapter 8) over the longer term. Also, the Project Crew Leader for each protocol (from the Temporary Staff described in Chapter 8) is responsible for supervising crew members to ensure their field data collection and management obligations are met, including data verification and documentation. Further details on the staffing plan are in Chapter 8, and a detailed explanation of roles and responsibilities for Network and project information management is located in the Information Management Plan (see Table 2.2 and Appendix 6.1, *NCBN_Information Management Plan*).

Chapter 8
Administration and Implementation of the Monitoring Program

8.1 Network Administration and Oversight

The Northeast Coastal and Barrier Network is one of 32 Networks in the NPS Inventory and Monitoring Program, and is part of a group of 12 Networks that were funded first, and are scheduled to complete the Phase III Report (Vital Signs Monitoring Plan) this year. The Network is accountable to the eight Network parks through the Board of Directors and through direct cooperation with park management and staff. Technical oversight is provided by the Network's Technical Steering Committee.

The Northeast Region has four Networks under the direction of a Regional Coordinator (Elizabeth Johnson). The program is included in the Natural Resource and Stewardship division of the Northeast Region Support Office (NESO). The Regional Coordinator is supervised by one of the Northeast Regional Chief Scientists (Mary Foley) and is directly responsible for ensuring that the Networks meet goals and conform to guidelines established by the National Inventory and Monitoring Program.

8.2 Board of Directors

The Network Board of Directors is comprised of 7 park superintendents, the Northeast Region Inventory and Monitoring Coordinator, the Network Coordinator, and the two Northeast Regional Chief Scientists. The Board of Directors pursues a holistic approach in defining Network management issues and resources of concern and assists with the identification of the best places to monitor these resources using scientifically credible standards. The major responsibilities of the Board of Directors are:

- Require accountability and effectiveness for the I&M Program by reviewing progress, quality control, and spending of Network funds.
- Provide guidance to the Network Coordinator, Network Data Manager, Technical Steering Committee and natural resource staffs of the Network's parks in the purpose, design and implementation of vital signs monitoring and other management activities related to the Natural Resource Challenge.
- Decide on strategies and procedures for leveraging Network funds and personnel to best accomplish inventory and monitoring and other natural resource needs of Network parks.
- Consult on hiring Network personnel using funding provided to the Network, including base funds and other sources.
- Seek additional financial support to leverage Servicewide funds.
- Solicit professional guidance from and partnerships with other governmental agencies, organizations and individuals.
- Serve as advocates for the Natural Resource Challenge and promote understanding of the importance of the Inventory and Monitoring program among park staff, visitors and decision makers.

8.3 Technical Steering Committee

The Network Technical Steering Committee has been formed to provide technical assistance and advice to the Board in developing and implementing a long-term monitoring strategy. This committee (10-12 members) is comprised of Network natural resource managers and biologists and other scientists from outside of the NPS who work in the parks and are familiar with park issues. The Technical Steering Committee has been or is currently responsible for:

- compiling and summarizing existing information about park resources
- developing materials for and summarizing the findings and recommendations of any scoping workshops held to develop a Network monitoring strategy
- participating in the identification of monitoring objectives and development of the Network Strategic Plan
- assisting in the selection of vital signs
- coordinating peer review of protocols
- evaluating initial sampling designs, methods and protocols
- reviewing annual reports and interpretation as well as participating in the preparation of the Annual Work Plan and Annual Report
- developing materials for and facilitating the Program and Protocol Review (see Chapter 7)
- designing position descriptions and hiring Network personnel

The Network Coordinator will present the products and recommendations of the Technical Steering Committee to the Board by for discussion and approval or modification.

When needed, the Board, Technical Steering Committee, Network Coordinator and/or the Regional I&M Coordinator may form groups of specialists to work on a particular task or a particular sub-program area. No such group will be formed without inclusion of a specific "sunset" provision.

8.4 Current Network Staff and Support Personnel

The Northeast Coastal and Barrier Network staff currently includes five National Park Service employees and three staff working through Cooperative Agreements (see Table 8.1). Permanent NPS positions are held by the Network Coordinator, the Data Manager, and a Geographer/GIS Specialist in charge of the Geomorphologic Change project. The NPS term positions include a staff biologist and a database developer; it is anticipated that the biologist (Marc Albert) will continue with the Network at least through the remaining two years of his appointment but that the database developer (Susan Huse) will terminate her position with the Network at the end of calendar year 2004. The three additional employees include two part-time research associates and a technical writer/editor. The research associates were contracted through a Cooperative Agreement with the University of Rhode Island to help with NPSpecies, database development and support, webpage development, and general logistic support. The technical writer/editor has been retained by a Cooperative Agreement with the Rocky Mountain Biological Lab to assist in the preparation of the final monitoring plan, the data management plan, and the protocols. Additional Cooperative and Interagency agreements have been established with academic institutions and the US Geological Service to develop protocols (see Table 8.4).

Table 8.1 Current Northeast Coastal and Barrier Network Staff

Employee	Position	Series & Grade	Duty Station	Position Type
Bryan Milstead	Network Coordinator	GS-0401-12	University of Rhode Island	Permanent
Sara Stevens	Data Manager	GS-0401-11	University of Rhode Island	Permanent
Mark Duffy	Geographer/GIS Specialist	GS-0150-12	Assateague Island N.S.	Permanent
Marc Albert	Biologist	GS-0401-11	Northeast Regional Office (Boston)	Term
Susan Huse	Database Developer	GS-0401-11	University of Rhode Island	Term
Linda Fabre	Research Associate	Cooperator	University of Rhode Island	Temporary
Dennis Skidds	Research Associate	Cooperator	University of Rhode Island	Temporary
Gary Entsminger	Technical Writer	Cooperator	Rocky Mountain Biological Lab	Temporary

8.4.1 Proposed Network Staffing Plan

An overview of the proposed Network staffing plan is presented in Figure 8.1 and Table 8.2. This plan is based on current projections of personnel needs for monitoring and will not be fully realized until fiscal year 2006. As a result of the changing dynamics involved in a developing a Network monitoring program, there may be a need to reassess and modify the staffing structure once the final monitoring plan is approved and implementation begins. This staffing plan forecasts our employment needs, but is designed to be flexible in order to satisfy unanticipated project staffing or operational needs. In order to maintain flexibility during the transition from planning to implementation, the plan relies heavily on contract, seasonal, and term employees. It is anticipated that some of these positions will be converted to permanent NPS positions once the long term program and project needs have been validated.

The Network Coordinator and the Information Coordinator (data manager) will work together as the administrative staff to manage Network operations. These are permanent NPS positions that will be duty stationed at the University of Rhode Island. The Network Coordinator will supervise the science staff and have the ultimate responsibility for administrative decisions and for guiding the Network towards satisfactory completion and delivery of all required reports and products. The Information Coordinator will manage, maintain and distribute data and information produced by the Network to parks, cooperators, national and regional NPS offices, and the public. The Information Coordinator will also supervise the permanent technical staff and will assure that data collection and reporting by the science staff meets the requirements of the Network's data management plan.

The science staff will consist of three positions, a Geographer/GIS Specialist and two biologists. These staff will oversee the collection and analysis of monitoring data and will be responsible for the annual and trend reports for each vital signs monitoring project (see Chapter 7). The science staff will work closely with the technical staff in the planning of field work and in entering the data into electronic databases. The Geographer/GIS position is a permanent position duty stationed at Assateague Island NS. The Network will hire two non-permanent biologists to serve as project leaders. One will be a term position and the second will be a contract position hired through a Cooperative (or Interagency) Agreement. This will provide the Network with both the stability and organizational expertise of an NPS biologist as well as the administrative flexibility associated with a cooperator. Duty stations for the biologists have not been finalized, and options include the University of Rhode Island, Network parks, or the NPS Northeast Regional Offices.

The temporary and seasonal staff will be employed as needed to complete field work and special projects. The Network employs university students as seasonal staff through the STEP Program (Student Temporary Employment Program). Interns are also available through the University of Rhode Island "Coastal Fellows" program and the Student Conservation Association. Temporary staff will be duty stationed at the University of Rhode Island or in Network parks depending on the needs of the program.

Table 8.2 Proposed staff for the Northeast Coastal and Barrier Network

Position	Series & Grade	Duty Station	Position Type
Network Coordinator	GS-0401-12	University of Rhode Island	Permanent
Data Manager /Information Coordinator	GS-0401-11	University of Rhode Island	Permanent
Geographer/GIS Specialist	GS-0150-11	Assateague Island N.S.	Permanent
Term Biologist	GS-0401-11	To be determined	Term
Contract Biologist	GS-0401-11 equivalent	To be determined	Contract
GIS/Biological Technician	GS-0401-09	University of Rhode Island	Permanent
Database/Biological Technician	GS-0401-09	University of Rhode Island	Permanent
Biological Technicians (2-4 people employed seasonally)	GS-0401-05/07	To be determined	Seasonal
Students and Interns	Cooperators or STEP employees	To be determined	Temporary

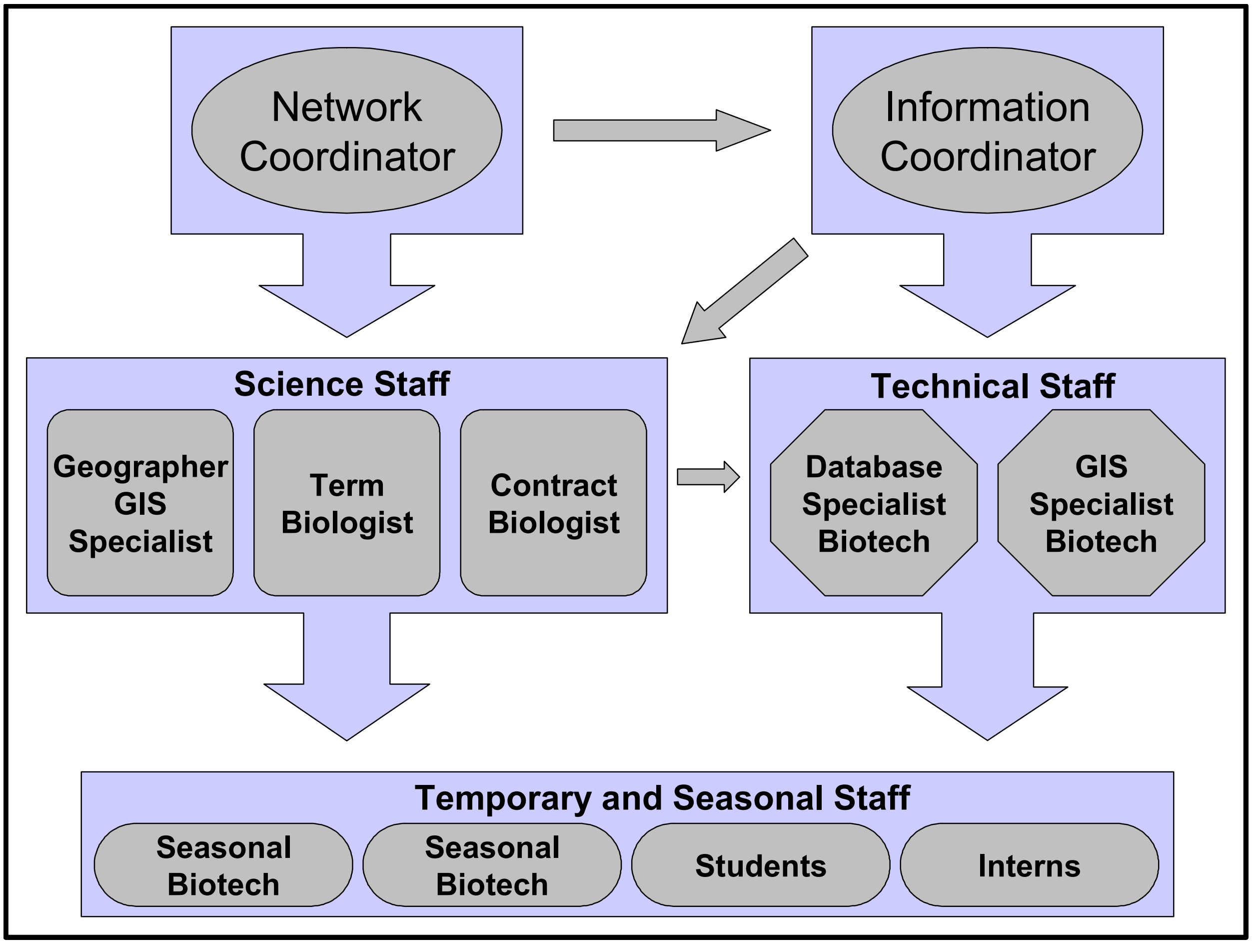

Figure 8.1 Network organizational plan (Arrows indicate supervisory requirements)

8.4.2 Proposed Network Staff Roles and Responsibilities

8.4.3 Network Administrative Staff

The *Network Coordinator* manages all aspects of the Network inventory and monitoring program. The primary role of the Network Coordinator is to serve as an advocate for the program and to maintain close communication among the diverse constituents that comprise the Network. Under the supervision of the Network Board of Directors, the Network Coordinator is responsible for budget tracking and forecasting, administering agreements and contracts, and personnel management. The Network Coordinator works closely with the Information Coordinator, Network Technical Steering Committee, and the Science Staff to obtain high quality information on the health of park ecosystems and to make these data available to resource managers and park management. The Network Coordinator must maintain regular contact with Park Superintendents and resource managers to insure that scientifically credible data and analyses are available and useful. The Network Coordinator will:

- direct all aspects of the Network Inventory and Monitoring Program
- have primary responsibility for the attainment of relevant Park, Network, Regional, and National Inventory and Monitoring Goals
- manage and report on the budget

- administer contracts, interagency agreements, and cooperative agreements
- hire and supervise the Network staff
- serve on the Network Board of Directors and Technical Steering Committee
- identify and prioritize regional and individual park inventory and monitoring needs
- obtain and apply information that contributes to understanding and managing park resources
- identify qualified researchers and potential cooperators to address gaps in the program
- oversee the preparation of reports, agreements, contracts, and all written products of the Network
- seek additional funding sources and opportunities for collaboration to strengthen the overall ability of the program to obtain and distribute inventory and monitoring information for the Network parks
- serve as an advocate for the program and maintain close communication among the diverse constituents that comprise the Network

The *Information Coordinator* works with national and regional Inventory and Monitoring Program data management staff and regional resource information management personnel to maintain a high-level of involvement in service-wide and regional databases and data management policy. The Network Information Coordinator works locally with Network personnel, park staff, and cooperators to promote and develop workable standards and procedures that result in the integration and availability of datasets.

The Information Coordinator also supervises the technical staff and ensures that all vital signs monitoring data is collected, managed and maintained according the Inventory and Monitoring Program standards. The data management responsibilities for this position are exhaustively detailed in the Network's Data Management Plan. In addition to assigned data management duties the Information Coordinator also serves as the chief advisor to the Network Coordinator and participates in all aspects of the programmatic, financial, and logistic planning to ensure that the goals and of objectives of the Network are achieved, and participates in the writing, editing, and distribution of all written products of the Network. The Network Information Coordinator will:

- understand and determine program and project data requirements, to ensure data and information resources are organized, available, useful, compliant, and safe
- provide overall Network planning, training, and operational support for the awareness, coordination, and integration of data and information management activities, including personnel needs, information needs, and data, software, and hardware needs
- coordinate Network and external data management activities
- supervise the Network Technical Staff of GIS and Database technicians
- coordinate efforts of Network biologists and cooperators involved in data acquisition, entry, or storage
- serve as Point of Contact for National Park Service database applications (e.g. NPSpecies)
- assist the Network Coordinator in the leadership of the Network
- participate in the preparation of reports, agreements, contracts, and all written products of the Network

8.4.4 Network Science Staff

The three Science Staff members will serve as project leaders responsible for the implementation, analysis and reporting of the Network's monitoring protocols. It is essential that each person have a detailed understanding of the subject area, goals and objectives, methods, data management needs, and reporting requirements for each protocol they administer (see Table 8.3).

The *Geographer/GIS specialist* will serve as the project lead for the protocols in the Geomorphologic Change and Landscape Change projects (see Table 8.3). As a result of the high level of technical skill required for the position this person will also work closely with the Information Coordinator and technical staff on all aspects of spatial data creation, storage and distribution for the Network for these projects.

The *Term and Contract Biologists* will manage the protocols from the three other projects (see Table 8.3). The term position will likely be converted to permanent to provide organizational knowledge and continuity for the projects and the Network, whereas the need for the contract position will be evaluated annually. The advantage of a contract position is that it can be used to fill gaps in expertise and programmatic needs without a long-term budget commitment. For example, one person may be ideal for the preparation of the Estuarine Eutrophication trend report and another may be better for the Visitor Use and Impacts project.

Science staff will work closely with the administrative and technical staff in the hiring, training, and supervision of seasonal technicians, interns, and students. The science staff will be directly supervised by the Network Coordinator. Science staff will be expected to adhere to the standards and guidance in the Data Management Plan (see Chapter 6); all activities related to the acquisition, storage, and dissemination of data will be supervised by the Information Coordinator. Specifically, the science staff members will be responsible for:

- preparation of annual work plans that specify the details of when, where, and who will collect, process, archive, and analyze all data for each project
- preparation of annual reports for each project (see also Chapter 7) that include:
    - project documentation that describes the 'who,' 'what,' 'where,' 'when,' 'why,' and 'how' of the project
    - documentation of the implementation of standard operating procedures for field data collection and data handling
    - quality assurance and quality control measures, which include the supervision and certification of all field operations, staff training, equipment calibration, species identification, data collection, data entry, verification, and validation
    - documentation of all deviations from standard procedures
    - detailed documentation for each field data collection period
    - details on the maintenance of hard copies of data forms and archiving of original data forms
    - scheduling of regular project milestones such as data collection periods, data processing target dates, and reporting deadlines

- completion of trend reports for each project on a six year cycle (see Chapter 7)
- acting as the main point of contact concerning field work and data content

- participation with and supervision of technical and temporary staff during all phases of data collection and data entry

Table 8.3 Task assignments for the Science Staff. Staff member will serve as project leaders for the indicated monitoring protocols

	Estuarine Eutrophication Project	Salt Marsh Vegetation Protocol	Salt Marsh Nekton Protocol	Salt Marsh Elevation Protocol	Shoreline Change Protocol	Coastal Topography Protocol	Visitor Use and Impacts Project	Landscape Change Project
Geographer/GIS Specialist					X	X		X
Term Biologist		X	X				X	
Contract Biologist	X			X				

8.4.5 Network Technical Staff

Two permanent technical positions will be established and duty stationed at the University of Rhode Island. The responsibilities of these positions will be split between data collection and data management. The nature of the work will require that candidates have adequate training as field biologists and a high level of technical skill in either GIS or database applications. The primary supervisor for these positions will be the Information Coordinator. However, the science staff will oversee the technical staff during field phases of the work.

As biological technicians, the technical staff will collaborate with the science staff in the completion of all field work and may serve as crew leaders for temporary and seasonal staff. The advantages of having permanent full-time technical staff are that:

- staff will be continually available for field work allowing for data collection outside of regular seasonal work periods
- technical staff will ensure continuity during data collection and entry phases
- any protocol drift that can result from hiring and training new staff each year will be minimized
- the Network will continue to receive benefits from investments in training

The biological technician duties will include:

- following project protocols, study plans, and relevant NPS guidance
- recording measurements and observations based on project objectives and protocols
- review, verification, and correction of field data
- assisting with data and procedural documentation, especially deviations from the protocol or study plan
- collaboration with science staff in the scheduling of time and resources
- the maintenance, repair, and storage of field equipment

- participation in regular required training for the use and maintenance of field equipment
- supervision of seasonal and temporary staff

As data management specialists the technical staff will be responsible for ensuring the compatibility of project data with program standards, for designing the infrastructure for the project data, and for working with the Information Coordinator to ensure long-term data integrity, security, and availability. Technical staff will be expected to collaborate extensively, however one will work primarily with spatial (GIS) data and the other will concentrate on tabular data.

The *Database specialist/Biotech* will manage tabular data associated with Network projects and assist with other data related to park resources. This person will design and populate relational databases, maintain data standards, and be responsible for sharing and disseminating the data throughout the Network. The position will require advanced knowledge of relational database concepts and software.

The Database Specialist will:

- develop and maintain the infrastructure for metadata creation, project documentation, and project data management
- create and maintain project databases in accordance with best practices and current program standards
- provide training in the theory and practice of data management tailored to the needs of project personnel
- develop ways to improve the accessibility and transparency of digital data
- establish and implement procedures to protect sensitive data according to project needs
- collaborate with the GIS Specialist to integrate tabular data with geospatial data in a GIS system in a manner that meets project objectives

The Database Specialist will also work closely with the Network staff to:

- define the scope of the project data and create a data structure that meets project needs
- become familiar with how the data are collected, handled, and used
- review quality control and quality assurance aspects of project protocols and standard procedure documentation
- identify elements that can be built into the database structure to facilitate quality control, such as required fields, range limits, pick-lists and conditional validation rules
- create a user interface that streamlines the process of data entry, review, validation, and summarization that is consistent with the capabilities of the project staff
- develop automated database procedures to improve the efficiency of the data summarization and reporting process
- make sure that project documentation is complete, complies with metadata requirements, and enhances the interpretability and longevity of the project data;
- ensure regular archival of project materials
- inform project staff of changes and advances in data management practices

The *GIS specialist/Biotech* will have primary responsibility for spatial data and will need advanced understanding of GIS software and concepts. This position will manage spatial data themes associated with Network projects, as well as other spatial data related to the full range of park resources. They incorporate spatial data into the GIS. They also maintain standards for geographic data and are responsible for sharing and disseminating GIS data throughout the Network.

The GIS specialist will:

- determine the GIS data and analysis needs for projects
- develop procedures for field collection of spatial data including the use of GPS and other spatial data collection techniques
- display, analyze, and create maps from spatial data to meet project objectives
- properly document data in compliance with spatial metadata standards

GIS specialists will also work directly with the Network Staff to:

- design databases and other applications for the Network
- create relationships between GIS and non-spatial data
- create database and GIS applications to facilitate the integration and analysis of both spatial and non-spatial data
- establish and implement procedures to protect sensitive spatial data according to project needs
- develop and maintain an infrastructure for metadata creation and maintenance
- ensure that project metadata are created and comply with national and agency standard

8.4.6 Network Temporary Staff

The temporary staff will serve as the primary field staff for data collection for most monitoring projects. Most if not all temporary staff will work in a seasonal schedule that is linked to the project on which they are working. The number of seasonal staff may fluctuate year to year depending upon the protocols that are being implemented and the parks in which data collection will occur. The specific needs for field staff are outlined in each protocol (see Chapter 5). In order to ensure that sufficient qualified personnel are available, the Network will utilize several sources to fill these positions, including:

- seasonal NPS Biological Technicians, including those available through the Student Temporary Employment Program (STEP)
- interns through the University of Rhode Island Coastal Fellows Undergraduate Intern program or other regional universities
- Student Conservation Association interns

For some projects it may be necessary to hire field staff with more advanced knowledge, in which case NPS seasonal Biological Technicians can be hired through open searches or through the Student Continuing Education Program (SCEP).

8.5 Implementation of the Vital Signs Monitoring Program

8.6 Partnerships

All five of the Network's vital signs monitoring projects are being developed in coordination with university-based partners (see Table 8.4). The Network has established Cooperative Agreements with each of the associated universities or institutions, and Interagency Agreements with the USGS. In addition, an agreement has been established with the Rocky Mountain Biological Lab for the technical writing services of Dr. Gary Entsminger in order to complete this plan (see Table 8.4).

Table 8.4 Cooperators Participating in the Development of NCBN Vital Signs Monitoring Protocols

Cooperator	Institution	Project
Dr. John Brock	USGS	Geomorphologic Change
Dr. Norb Psuty	Rutgers University	
Dr. Don Cahoon	USGS	Salt Marsh
Dr. M.J. James-Pirri	University of Rhode Island	
Dr. Hilary Neckles & Dr. Blaine Kopp	USGS	Estuarine Eutrophication
Dr. Scott Nixon	University of Rhode Island	
Dr. Chris Monz	St. Lawrence College	Visitor Use and Impacts
Dr. Yu-Fei Leung	North Carolina State University	
Dr. YQ Wang	University of Rhode Island	Landscape Change

8.7 Integration of the Monitoring Program with Park Management and Operations

An active partnership between Network and park staff as well as participating cooperators is essential for the success of the vital signs monitoring program. The primary goal of the monitoring program is to provide useful information for park managers. The Network and parks have worked together at various levels throughout the planning and development of vital signs monitoring protocols, and will continue to do so as projects are implemented.

On an operational level, the implementation of most protocols will require logistical coordination between project and park staff. With the exception of the Landscape Change project and the Estuarine Nutrient Inputs protocol, which will utilize external data sources, data collection will take place in the parks. Pilot sampling has occurred in many parks for all three of the Salt Marsh project protocols, as well as for the Ecosystem Indicators of Estuarine Eutrophication, Shoreline Position and Coastal Topography protocols. These pilot sampling operations have served as a scoping effort for many of the on-the-ground logistical considerations. For example the use of park boats at Fire Island NRA and Gateway NRA for the Salt Marsh and Estuarine Eutrophication projects.

The current draft protocols for the most part do not require the use of park equipment or staff, but do in some cases call for the purchase of equipment that will be stored at parks, such as all terrain vehicles for use in the Shoreline Position protocol. This is one of several examples of Network equipment that may be utilized by parks beyond the monitoring projects. Also, there will be sharing of park and Network equipment and other resources for Network staff that will be duty stationed at parks, such as the Network Geographer / GIS Specialist who is stationed at Assateague Island NRA. The final protocols for each project will provide details in the Standard Operating Procedures regarding such elements as the storage of equipment, notification of park law enforcement, and acquiring access to closed areas. Since several of the protocols are still being developed, and the Network staff is proposed to change, there will be further needs for coordination and opportunities for cooperation between and among parks and the Network.

The Network is committed to providing up to date information about the health of park resources to all levels of park staff in order to improve park management and operations. See Chapter 7 for details on the reports that will be produced. All projects should be valuable for natural resource management, but some projects may provide useful information to other park divisions. For example data collected for the Visitor Use and Impacts project may be valuable for park law enforcement, trail maintenance, or cultural resource management, and the analyses produced by the Geomorphologic Change project should be very useful for park infrastructure planning.

Cape Cod NS is a prototype park for the Inventory and Monitoring Program that has been developing projects for several years, and has staff dedicated to monitoring projects including but not limited to those described in this plan. Therefore, there is much more integration of park operations and monitoring project implementation at Cape Cod NS that there will be at other Network parks.

8.8 Equipment, Training, and Safety

All federal regulations as well as all procedures from the Department of the Interior and National Park Service regarding safety and training will be adhered to during the implementation of all protocols. In addition, each vital signs monitoring protocol will outline the procedures for the safe use of any necessary equipment. The occupational safety and health standards for all federal employees are located in Title 29 of the Occupational Safety and Health Administration regulations at CFR 29, Part 1910. The Department of the Interior's Safety and Occupational Health Manual, DM 485, provides more detailed departmental standards, and the Department's Safety Net website is a useful location for health and safety policy and information.

The NPS safety information portal is called RiskNet, which provides many valuable links such as to the NPS Safety Management Information System, the NPS Incident Management Analysis & Reporting Program, and Directors Orders regarding Workers Compensation, Occupational Safety and Health, and Public Safety. One important NPS safety document that will be followed for all projects is the "minimum program requirements" for providing safety and managing risk at work sites.

Probably the most important safety standards for the implementation of monitoring protocols are those relating to motor vehicle, aircraft, and boat use. All staff or contractors will meet the minimum requirements for operating motor vehicles and receive training as necessary, as detailed in the Department of the Interior (DOI) motor vehicle safety standards in the Departmental Manual.

Aircraft will likely be utilized for data collection through the Coastal Topography protocol of the Geomorphologic Change project, and possibly for the data collection through the Landscape Change protocol. The Departmental Manual provides standards for aircraft safety at Section 352 DM 15 that direct the NPS to provide safe working conditions, prevent injuries to employees, and protect property from damage. In October 2001, the Office of Aircraft Services (OAS) was realigned under the Department of the Interior, National Business Center as the Aviation Management Directorate (AM).The Aviation Management safety website provides information on the Interior Aviation User Training Program which "identifies minimum aviation management and user training requirements for personnel participating in aviation activities conducted by DOI." All personnel involved with aviation use in support of Network projects will receive proper training before participation.

Similarly, all personnel operating boats in association with the Estuarine Eutrophication, Salt Marsh, or other projects will follow the standards and requirements of DOI and NPS. Minimum requirements for the safe operation of DOI watercraft and for the certification of watercraft operators are found in Department Manual, Part 485, Safety and Occupational Health Program, Chapter 22, Watercraft Safety. Under these requirements, all DOI staff that operate watercraft must be certified via the Motorboat Operator Certification Course, and must maintain their certification status with a refresher course. Network parks require that all contractors who operate boats in the parks also meet these standards.

8.9 Periodic Program and Protocol Review

The NCBN program will be reviewed and graded annually as part of the National Inventory and Monitoring Program procedures. In addition, a thorough review and report on the Network and all of the vital signs monitoring protocols will be completed every six years, as part of the six year cycle of trend reporting for each of the vital signs projects (see Table 7.1). See Chapter 7 for additional details.

Chapter 9
Schedule

9.1 Planning and Implementation Schedule for Vital Signs Monitoring Projects

Four draft monitoring protocols, representing three of the five vital signs monitoring projects, have been completed and are submitted with this report (Ecosystem Indicators of Estuarine Nutrients, Shoreline Position, Salt Marsh Vegetation, and Salt Marsh Nekton):

- Appendix 5.1, *NCBN_GeomorphologicChange_PDS*
- Appendix 5.2, *NCBN_EstuarineEtrophicationNutrientInputs_PDS*
- Appendix 5.3, *NCBN_SaltMarshVegetation_PDS*
- Appendix 5.4, *NCBN_SaltMarshNekton_PDS*

Six additional protocols are in development and will be completed over the next three years. The expected completion dates for draft and final protocols, as well as additional key tasks associated with each monitoring project, are summarized in Table 9.1.

The frequencies, time of year, and park locations for data collection vary among projects and protocols, depending upon the selected vital signs, the monitoring questions, and the sampling designs (see chapters 4 and 5 as well as protocol summary and draft protocol Appendix 9.1, *Draft CACO Sediment Elevation Protocol*). Table 9.2 summarizes data collection for all projects. Tables 9.3, 9.4, and 9.5 provide park-specific data collection schedules for Geomorphologic Change, Salt Marsh, and Estuarine Eutrophication projects.

Table 9.1 Timeline for Completion of Protocols and Additional Key Tasks for Vital Signs Monitoring Projects

Project	Protocol	Planning Workshop or Meeting	Pilot Sampling	Draft Protocol Completion Date	Final Protocol Completion Date
Geomorphologic Change	Shoreline Position		Data Available	December-04	October-05
	Coastal Topography		Data Available	October-05	March-06
Salt Marsh	Salt Marsh Nekton		Complete	December-04	October-05
	Salt Marsh Vegetation		Complete	December-04	October-05
	Salt Marsh Elevation		Complete	October-05	March-06
Estuarine Eutrophication	Ecosystem Indicators of Eutrophication		Complete	December-04	October-05
	Estuarine Nutrient Inputs	January-05	Complete	October-05	March-06
Visitor Use and Impacts	Park Use as an Agent of Change	January-05	Summer-06	January-06	December-06
	Visitor Impacts to Park Resources	January-05	Summer-06	January-06	December-06
Landscape Change	Landscape Change	Spring-05	Ongoing	December-06	October-07

Table 9.2 Data Collection Schedule Summary for Vital Signs Monitoring Protocols

Project	Protocol	Park								General Data Collection Schedule
		ASIS	CACO	COLO	FIIS	GATE	GEWA	SAHI	THST	
Geomorphologic Change	Shoreline Position	X	X		X	X				Twice annually in Spring and Fall
	Coastal Topography	X	X	X	X	X	X	X		Lidar surveys every two years, field surveys annually
Salt Marsh	Salt Marsh Nekton	X	X	X	X	X	X	X		Every three years in late Summer
	Salt Marsh Vegetation	X	X	X	X	X	X	X		Every three years in late Summer
	Salt Marsh Elevation	X	X	X	X	X	X			Three times annually
Estuarine Eutrophication	Ecosystem Indicators of Eutrophication	X	X	X	X	X	X	X		Annually during a one month Summer index period
	Estuarine Nutrient Inputs	X	X	X	X	X				Every 10 years
Visitor Use and Impacts	Park Use as an Agent of Change	X	X	X	X	X	X	X	X	To be determined
	Visitor Impacts to Park Resources	X	X	X	X	X	X	X	X	To be determined
Landscape Change	Landscape Change	X	X	X	X	X	X	X	X	Every 5-10 years – to be determined

9.1.1 Geomorphologic Change

The draft Shoreline Position (see Appendix 9.1, *Draft CACO Sediment Elevation Protocol*) protocol has been completed, and historic and project pilot sampling data from both GPS and land survey methods are available for all four parks in which the protocol will be implemented (see Tables 9.2 and 9.3). The Coastal Topography protocol is being actively developed and a draft is expected to be completed by October 2005. Pilot sampling and testing of experimental equipment for this protocol has been ongoing in association with USGS and NASA, and the results of this testing will determine the content of the protocol and the timing of field data collection.

Table 9.3 Expected Field Sampling Schedule for Shoreline Position (SP) and the Coastal Topography (includes field surveys [CTF] and Lidar surveys [Lidar]) Protocols of the Geomorphologic Change Project. Note that Shoreline Position data collection occurs twice annually.

Park →	ASIS	CACO	COLO	FIIS	GATE	GEWA	THST	SAHI
Year ↓								
2005	SP, CTF, Lidar	SP, CTF, Lidar	Lidar	SP, CTF, Lidar	SP, CTF, Lidar	Lidar		Lidar

2006	SP, CTF, Lidar	SP, CTF	Lidar	SP, CTF	SP, CTF	Lidar		
2007	SP, CTF	SP, CTF, Lidar		SP, CTF, Lidar	SP, CTF, Lidar			Lidar
2008	SP, CTF, Lidar	SP, CTF	Lidar	SP, CTF	SP, CTF	Lidar		
2009	SP, CTF	SP, CTF, Lidar		SP, CTF, Lidar	SP, CTF, Lidar			Lidar
2010	SP, CTF, Lidar	SP, CTF	Lidar	SP, CTF	SP, CTF	Lidar		
2011	SP, CTF	SP, CTF, Lidar		SP, CTF, Lidar	SP, CTF, Lidar			Lidar
2012	SP, CTF, Lidar	SP, CTF	Lidar	SP, CTF	SP, CTF	Lidar		
2013	SP, CTF	SP, CTF, Lidar		SP, CTF, Lidar	SP, CTF, Lidar			Lidar

9.1.2 Salt Marsh

Both Salt Marsh Vegetation and Salt Marsh Nekton (see Appendix 5.3, *NCBN_SaltMarshVegetation_PDS* and Appendix 5.4, *NCBN_SaltMarshNekton_PDS*) draft protocols have been completed and are submitted along with this report, and field sampling is expected to begin in 2005. These protocols are being developed in coordination with the Northeast Temperate Network (NETN), and field sampling will be conducted in groups of nearby parks on a three year rotation.

Field sampling will begin in 2005 at Assateague Island NRA, Colonial NP, and George Washington Birthplace NM (in addition to Acadia NP in the NETN), continue in 2006 at Fire Island NS, Gateway NRA, and Sagamore Hill NHP, and the third and final group of parks, including Cape Cod NS (as well as Boston Harbor Islands National Park Area and Saugus Iron Works NHP), will be sampled in 2007 (see Tables 9.2 and 9.4). The Salt Marsh Elevation protocol will be completed in 2005. A protocol has been completed for Cape Cod NS through their Prototype Park Long Term Ecological Monitoring Program (see Appendix XX for reference only). This will be used as a template to complete a draft protocol for the Network by October 2005 (Table 9.1).

Table 9.4 Expected Field Sampling Schedule for the Salt Marsh Vegetation (V), Salt Marsh Nekton (N) and Salt Marsh Elevation (E) Protocols of the Salt Marsh Project

Park → / Year ↓	ASIS	CACO	COLO	FIIS	GATE	GEWA	THST	SAHI
2005	V, N, E	E	V, N, E	E	E	V, N, E		
2006	E	E	E	V, N, E	V, N, E	E		V, N
2007	E	V, N, E	E	E	E	E		
2008	V, N, E	E	V, N, E	E	E	V, N, E		
2009	E	E	E	V, N, E	V, N, E	E		V, N
2010	E	V, N, E	E	E	E	E		
2011	V, N, E	E	V, N, E	E	E	V, N, E		
2012	E	E	E	V, N, E	V, N, E	E		V, N
2013	E	V, N, E	E	E	E	E		

9.1.3 Estuarine Eutrophication

The Ecosystem Indicators of Estuarine Eutrophication protocol is complete and submitted along with this report. Pilot sampling has been conducted at Cape Cod NS, Fire Island NRA, Gateway NRA, and Colonial NP. A complete pilot run of the model used to estimate inputs for the Estuarine Nutrient Inputs protocol has been completed. A final report on the model run will be followed by a meeting to determine the content of the protocol in early 2005, and the draft protocol is expected to be completed by October 2005 (Table 9.1). The expected data collection schedules for these protocols are found in Tables 9.2 and 9.5.

Table 9.5 Expected Data Collection Schedule for the Ecosystem Indicators of Estuarine Eutrophication Protocol (Indicators), and the Estuarine Nutrient Inputs Protocol (Inputs) of the Estuarine Eutrophication Project

Park → Year ↓	ASIS	CACO	COLO	FIIS	GATE	GEWA	THST	SAHI
2005	Indicators	Indicators	Indicators	Indicators	Indicators	Indicators		Indicators
2006	Indicators	Indicators	Indicators	Indicators	Indicators	Indicators		Indicators
2007	Indicators	Indicators	Indicators	Indicators	Indicators	Indicators		Indicators
2008	Indicators, Inputs	Indicators, Inputs	Indicators, Inputs	Indicators, Inputs	Indicators, Inputs	Indicators		Indicators
2009-2017	Indicators	Indicators	Indicators	Indicators	Indicators	Indicators		Indicators
2018	Indicators, Inputs	Indicators, Inputs	Indicators, Inputs	Indicators, Inputs	Indicators, Inputs	Indicators		Indicators

9.1.4 Visitor Use and Impacts

A workshop will be held in January 2005 with an interdisciplinary group including Network staff and park managers, experts in statistics and sampling designs for ecological applications, and recreation ecologists in order to clarify the direction of protocol development for the two protocols in this project. Following the workshop, agreements will be established with cooperating researchers to develop the protocols, drafts of which are expected to be completed by January 2006. Pilot sampling is expected to occur in 2006 and final protocols completed subsequently (Table 9.1). The sampling schedule will be determined as part of protocol development, however all Network parks are expected to be included (Table 9.2).

9.1.5 Landscape Change

The Network will continue to work with cooperator Y.Q. Wang to develop a strategy for protocol completion in association with the National Capital Region and the national Inventory and Monitoring Program's Land Use and Land Cover Change Workgroup. Dr. Wang will develop the Network protocol for all Network parks, including submerged habitats, in accordance with the guidelines and models that are being developed through the Workgroup (Table 9.2).

9.2 Reporting and Review Schedule for Vital Signs Monitoring Protocols

Annual project reports and trend reports (every 6 years) will be completed for each vital sign monitoring project. In addition, every 6 years the overall Network program and all of the project protocols will be reviewed and a summary report produced. Additional details on reports are provided in Chapter 7 and the reporting schedule is summarized in Table 7.1.

Chapter 10
Budget

Income

The Northeast Coastal and Barrier Network receives $776,500 annually from the NPS service-wide Inventory and Monitoring Program for vital signs monitoring and $90,000 annually from the NPS Water Resources Division for water quality monitoring (see table 10.1).

Table 10.1 Summary of the Network's income and the projected percent of income to be spent on by category for fiscal years 2006 to 2010.

	Fiscal Year				
Budget Item	**2006**	**2007**	**2008**	**2009**	**2010**
Income: Vital Signs Funds	$777	$777	$777	$777	$777
Income: Water Quality Funds	$90	$90	$90	$90	$90
Total Income	**$867**	**$867**	**$867**	**$867**	**$867**
Expense: Personnel	55%	57%	61%	64%	68%
Expense: Contract Personnel	12%	12%	13%	13%	14%
Expense: Travel	4%	4%	4%	4%	5%
Expense: Operations/Equipment	3%	3%	3%	4%	4%
Expense: Coop. Agreements	26%	23%	18%	13%	8%

Expenses

The percent of projected expenses to be allocated to personnel, contract personnel, travel, operation & equipment, and cooperative agreements is shown in Table 10.1. As expected, a large portion of the budget will be devoted to personnel. Salaries and benefits for NPS staff will cost between 55% and 68% of the budget. An additional 12% to 14% will cover the cost of contract personnel. Travel will account for approximately 5% of the budget. Operations and equipment will cost 3-4%. The remaining funds (8-26%) will be used to establish cooperative agreements for program enhancement or data acquisition and analysis.

Detailed personnel costs based on the Network staffing plan (Chapter 8) are presented in Table 10.2. These calculations are based on 2004 GS locality pay tables and assume a 4% cost of living increase per year with normal step increases. The contract personnel costs are extrapolated from current costs based on an agreement with the U.S. Geological Survey.

The projected budget for all Network operations over the next five years is shown in Table 10.3. The projection is based on current costs combined with estimates of the cost of monitoring. The Network has already invested in capital equipment to begin the implementation of projects. The Network currently owns two four-wheel drive vehicles, laptop computers for all personnel, three differential GPS units, and four automated water samplers. During fiscal year 2005, additional equipment will be purchased for the Estuarine Eutrophication (automated water samplers) and Geomorphologic Change (a cartography grade GPS unit and an all-terrain-vehicle) projects. The Network also shares with Assateague Island N.S a geodetic grade GPS unit.

Table 10.2 Personnel costs (in thousands of dollars) by fiscal year. Assumes 4% cost of living increase per year plus step increases for NPS personnel

	Fiscal Year				
Position	2006	2007	2008	2009	2010
Network Coordinator	$102	$106	$113	$118	$126
Data Manager	$82	$85	$92	$95	$102
Geographer/GIS Specialist	$84	$88	$94	$98	$105
Term Biologist	$82	$85	$92	$95	$102
GIS Specialist/BioTech	$46	$49	$53	$57	$59
Database Specialist/BioTech	$46	$49	$53	$57	$59
Seasonal Biotech	$17	$17	$18	$19	$20
Seasonal Biotech	$17	$17	$18	$19	$20
Contract Biologist	$98	$101	$109	$113	$121
Coastal Fellow	$4	$4	$4	$4	$4
Total Personnel	**$578**	**$601**	**$646**	**$675**	**$718**

Table 10.3 Total budget (in thousands of dollars) by fiscal year. Assumes a 4% increase per year for costs that are not fixed

		Fiscal Year				
Type of Expense	Budget Detail	2006	2007	2008	2009	2010
Personnel	NPS Personnel	$476	$496	$533	$558	$593
Coop. Agreements	Contract Personnel	$102	$105	$113	$117	$125
Coop. Agreements	URI Office Costs	$18	$18	$18	$18	$18
Travel	Travel	$34	$36	$37	$39	$40
Operations/Equipment	Computer Equipment	$7	$8	$8	$8	$9
Operations/Equipment	Vehicle Maintenance	$3	$3	$3	$4	$4
Operations/Equipment	Boat Use	$3	$3	$3	$4	$4
Operations/Equipment	Estuarine Eutrophication Equipment	$5	$5	$5	$6	$6
Operations/Equipment	Geomorphololgy Equipment	$5	$5	$5	$6	$6
Operations/Equipment	Saltmarsh Equipment	$3	$3	$3	$4	$4
Operations/Equipment	Visitor Impacts	$3	$3	$3	$4	$4

	Equipment					
Coop. Agreements	Lidar Data Acquisition	$40	$40	$40	$40	$0
Coop. Agreements	Satellite data acquisition	$30	$30	$30	$0	$0
Coop. Agreements	Data Archiving	$40	$40	$40	$40	$40
Coop. Agreements	Cooperative Agreements	$98	$72	$26	$19	$14
	Total Budget	**$867**	**$867**	**$867**	**$867**	**$867**

As required, the Network is making a strong commitment to data management. As demonstrated in Table 10.4, 20-80% of staff time and at least 30% of the budget will be devoted to data management. The Network will continue to expand data management through in-house capabilities and cooperative arrangements with academic institutions.

Table 10.4 Amount of the budget (in thousands of dollars) devoted to Data Management by fiscal year.

	Fiscal Year					**Percent of Resource**
Budget Detail	**2006**	**2007**	**2008**	**2009**	**2010**	
Network Coordinator	$20	$21	$23	$24	$25	**20%**
Data Manager	$66	$68	$74	$76	$82	**80%**
Geographer/GIS Specialist	$25	$26	$28	$29	$32	**30%**
Term Biologist	$16	$17	$18	$19	$20	**20%**
GIS Specialist/BioTech	$28	$29	$32	$34	$35	**60%**
Database Specialist/BioTech	$28	$29	$32	$34	$35	**60%**
Seasonal Biotech	$3	$3	$4	$4	$4	**20%**
Seasonal Biotech	$3	$3	$4	$4	$4	**20%**
Contract Biologist	$20	$20	$22	$23	$24	**20%**
Coastal Fellow	$1	$1	$1	$1	$1	**20%**
URI Office Costs	$5	$5	$5	$5	$5	**30%**
Travel	$7	$7	$7	$8	$8	**20%**
Computer Equipment	$4	$4	$4	$4	$5	**50%**
Data Archiving	$40	$40	$40	$40	$40	**100%**
Total Data Management Dollars	**$266**	**$276**	**$293**	**$305**	**$320**	
Percent of Total Budget	**31%**	**32%**	**34%**	**35%**	**37%**	

The Network's Estuarine Eutrophication project represents a major investment in water quality monitoring. As indicated by Table 10.4, approximately 20% of the budget will be devoted to this project. This cost will be covered in part by funds received from the Water Resources Division; the remainder will be paid from Vital Signs funds.

Table 10.5 Amount of the budget (in thousands of dollars) devoted to Water Quality (Estuarine Eutrophication Project) by fiscal year

	Fiscal Year					Percent of Resource
Budget Detail	**2006**	**2007**	**2008**	**2009**	**2010**	
Network Coordinator	$20	$21	$23	$24	$25	**20%**
Data Manager	$16	$17	$18	$19	$20	**20%**
GIS Specialist/BioTech	$9	$10	$11	$11	$12	**20%**
Database Specialist/BioTech	$9	$10	$11	$11	$12	**20%**
Seasonal Biotech	$9	$9	$9	$10	$10	**50%**
Seasonal Biotech	$9	$9	$9	$10	$10	**50%**
Contract Biologist	$49	$51	$55	$57	$61	**50%**
Coastal Fellow	$2	$2	$2	$2	$2	**50%**
Travel	$8	$8	$8	$9	$9	**30%**
Vehicle Maintenance	$1	$1	$1	$1	$1	**20%**
Boat Use	$2	$2	$2	$3	$3	**75%**
Estuarine Eutrophication Equipment	$5	$5	$5	$6	$6	**100%**
Data Archiving	$8	$8	$8	$8	$8	**20%**
Cooperative Agreements	$20	$14	$5	$4	$3	**20%**
Total Data Management Dollars	**$166**	**$165**	**$166**	**$173**	**$182**	
Percent of Total Budget	**19%**	**19%**	**19%**	**20%**	**21%**	

CHAPTER 11
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Glossary

Adaptive Management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form- "active" adaptive management-employs management programs that are designed to experimentally compare selected policies or practices, by implementing management actions explicitly designed to generate information useful for evaluating alternative hypotheses about the system being managed.

Agents of Change are the major external activities or processes that influence the natural system, which can be natural processes or human activities. In the NCBN general model, the agents of change are natural disturbance, land use, resource consumption, visitor and recreation use, and disasters.

Attributes are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem. The term Indicator is reserved for a subset of attributes that is particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). See Indicator.

Bathymetry is the measurement of water depths.

Ecological integrity is a concept that expresses the degree to which the physical, chemical, and biological components (including composition, structure, and process) of an ecosystem and their relationships are present, functioning, and capable of self-renewal. Ecological integrity implies the presence of appropriate species, populations and communities and the occurrence of ecological processes at appropriate rates and scales as well as the environmental conditions that support these taxa and processes.

Ecosystem is defined as, "a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries" (Likens 1992).

Ecosystem drivers are major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., earthquakes, droughts, floods) that have large scale influences on natural systems.

Ecosystem management is the process of land-use decision making and land-management practice that takes into account the full suite of organisms and processes that characterize and comprise the ecosystem. It is based on the best understanding currently available as to how the ecosystem works. Ecosystem management includes a primary goal to sustain ecosystem structure and function, a recognition that ecosystems are spatially and temporally dynamic, and acceptance of the dictum that ecosystem function depends on ecosystem structure and diversity. The whole-system focus of ecosystem management implies coordinated land-use decisions.

Ecosystem Responses are the measurable changes in ecosystem structure (biotic or physical), function, or processes.

Estuaries are aquatic environments in which ocean water and fresh water mix, including sub-tidal habitats and adjacent inter-tidal wetlands. Estuaries are usually semi-enclosed by land, and have open, partially obstructed, or sporadic access to the ocean.

Eutrophication is the process by which aquatic environments are altered through enrichment by mineral and organic nutrients, promoting a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the local reduction or extinction of other organisms.

Focal resources are park resources that, by virtue of their special protection, public appeal, or other management significance, have paramount importance for monitoring regardless of current threats or whether they would be monitored as an indication of ecosystem integrity. Focal resources might include ecological processes such as deposition rates of nitrates and sulfates in certain parks, or they may be a species that is harvested, endemic, alien, or has protected status.

Geomorphology is the study of the shape and form of the landscape, and how the nature of landforms relates to their origin, development, and change over time.

Hydrography is the science of the measurement, description and mapping of the surface waters of the earth.

I&M - Inventory and Monitoring, referring specifically to the National Park Service Inventory and Monitoring Program or related projects.

Indicators are a subset of monitoring attributes that are particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system.

Invasive Species are species that proliferate in an environment, dominating resources and/or displacing other species. This is generally used to mean species that display these tendencies following direct or indirect transport by humans to new environments.

LTEM – Long Term Ecological Monitoring. The Cape Cod National Seashore's monitoring program is one of several LTEM programs developed by prototype monitoring parks in the National Park system.

Lidar (LIDAR) – LIght Detection And Ranging. Lidar uses the same principle as RADAR. The lidar instrument transmits light out to a target. The transmitted light interacts with and is changed by the target. Some of this light is reflected / scattered back to the instrument where it is analyzed. The change in the properties of the light enables some property of the target to be determined. The time for the light to travel out to the target and back to the lidar is used to determine the range to the target. An airborne lidar platform is being tested for use as part of the NCBN Coastal Topography protocol.

Measures are the specific feature(s) used to quantify an indicator, as specified in a sampling protocol.

NCBN – Northeast Coastal and Barrier Network

NHP – National Historic Park, as in Colonial NHP

NHS – National Historic Site, as in Sagamore Hill NHS

NM – National Monument, as in George Washington Birthplace NM

NOAA – National Oceanic and Atmospheric Administration, part of the U.S. Department of Commerce.

NPS - National Park Service

NRA – National Recreation Area, as in Gateway NRA

NS – National Seashore, as in Assateague Island NS

Nekton are all free swimming organisms in an aquatic environment. For the purposes of the Salt Marsh Nekton protocol, nekton are fish and decapod crustaceans in Network park salt marshes.

Submerged Aquatic Vegetation (SAV) is the set of plant and seaweed (macroalgae) species that grow submerged in marine or estuarine habitats. Often used interchangeably with *seagrass*.

Sediment is matter deposited by a natural process, such as the movement of sand along beaches.

Stressors are physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level (Barrett et al. 1976:192). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include altered hydrology, altered landscape, invasive species, altered sediment and chemical inputs.

USGS – United States Geologic Survey, a bureau of the Department of the Interior.

Vital Signs, as used by the National Park Service, are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

303(b) – Section 303(d) of The Clean Water Act, which requires that states develop an Impaired Waterbodies List for waterbodies that do not meet the water quality standards that the states have set. This list comprises two types of waters: first, those in which water quality standards cannot be met because of the presence of toxic pollutants; second, those in which certain uses cannot be maintained or achieved. These uses include public water supplies, agricultural and industrial uses, the protection and propagation of a balanced population of shellfish, fish and wildlife, and recreational activities in and on the water.

305(b) - Section 305(b) of the Clean Water Act, which requires each state to complete a Water Quality Report every two years identifying impairments for waters within each state. Waters listed in the 305(b) report are referred to as 305(b) listed waters and can be found on the EPA's Water Quality Inventory Electronic 305(b) Report website (http://www.epa.gov/waters/305b/index.html).